ИНОСТРАННЫЙ ЯЗЫК

ПРОИЗВОДСТВО ЦВЕТНЫХ И РЕДКИХ МЕТАЛЛОВ

Методические указания к практическим занятиям для студентов магистратуры направления 22.04.02

FOREIGN LANGUAGE

MANUFACTURING OF NON-FERROUS AND RARE EARTH METALLS

САНКТ-ПЕТЕРБУРГ
2019

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Санкт-Петербургский горный университет

Кафедра иностранных языков

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ИНОСТРАННЫЙ ЯЗЫК. Производство цветных и редких металлов: Методические указания к практическим занятиям / Санкт-Петербургский горный университет. Сост. *И.С. Облова.* СПб, 2019**.** 44 с.

Методические указания предназначены для практических занятий со студентами магистратуры направления 22.04.02 «Металлургия» (направленность «Металлургия цветных металлов») и согласованы с программой по иностранному языку для студентов неязыковых вузов. Изучение предложенного материала направлено на совершенствование навыков просмотрового и коммуникативного чтения.

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ПРЕДИСЛОВИЕ

Данные методические указания по дисциплине "Иностранный язык" предназначены, прежде всего, для аудиторной работы студентов, обучающихся по направлению подготовки 22.04.02, а так же могут быть полезны для вузов технического профиля близких специальностей.

В соответствии с требованиями государственных программ Российской Федерации по профессиональной подготовке металлургов методические указания имеют целью развитие у обучающихся навыков и умений самостоятельно вести беседу с использованием металлургической терминологии, составлять доклады, научные статьи и рефераты по металлургии на английском языке.

Предложенные аутентичные материалы и разработанный комплекс упражнений к ним направлены на совершенствование навыков устной и письменной иноязычной речи в ситуациях профессионально-ориентированного общения. Тематика текстов затрагивает современные проблемы развития минерально-сырьевого комплекса.

Особое внимание уделяется накоплению активного словарного запаса, который включает наиболее употребительные для специальности термины и слова общетехнического значения. В приложении представлен список химических элементов, алгоритм чтения формул и уравнений химических реакций, глоссарий основных металлургических терминов. Методические указания состоят из 2 частей и приложения.

UNIT I METALS AND METALLURGY

TEXT A. Metals and nonmetals

TASK 1. Answer the following prediction questions.

1. How can chemical elements be classified?
2. What is a metal?
3. What properties do metals have?
4. Which metal reacts less vigorously with water?
5. When zinc is added into the blue colour copper sulphate solution, it turns?

TASK 2. Read the passage to see if your predictions were correct.

Among the more obvious distinctions between different kinds of elements is that, which divides metals and nonmetals. Metals are distinguished from nonmetals by their high conductivity for heat and electricity, by metallic luster and by their resistance to electric current increasing with increasing temperature. Their widespread use in industry is due not only to those properties, but also to the fact that their properties can be greatly altered by alloying with other metals, so as to increase their strength or improve other properties such as hardness, etc.

Engineers will tell you that metals are the only materials worth considering for constructing any mechanism or structure, which must have a high efficiency. This is because many metals and alloys have great strength and capability of withstanding limited overloading without catastrophic failure; in other words, they are tough. Metals can be cast into varied and intricate shapes weighing from a few ounces to many tons. Their plasticity, or ability to deform without rupture, makes them safe to use in all types of structures, and also allows their formation into required shapes through forging and other operations. Metals also possess the important property of being weldable. Of all the engineering materials only metals are truly weldable and repairable. Other materials used in engineering constructions, including glass, stone, and wood, usually are destroyed when the structure is no longer usable. On the other hand, an unusable bridge, ship, or boiler made of metal usually is cut into easily handled sections, put in a furnace, remelted, cast, and finally worked in the making of a new ship, bridge, or boiler.

According to the commercial classification which, unfortunately, does not have a scientific basis, all the metals are divided into very uneven groups; ferrous and non-ferrous metals. Iron and its alloys are classed as ferrous metals. Manganese and chromium used as addition to iron are ferrous metals too. From all metal goods, ferrous metals make up about 95 percent. The other metals are termed non-ferrous.

There are several important groupings of metals and of the alloys of which they are the major constituents. The common metals such as iron, copper, zinc, lead are produced in great quantities. The so-called precious metals include silver, gold, platinum, palladium, and indium. The light metals are aluminium, beryllium, magnesium and titanium. They are especially important in aircraft and rocket construction. The noble metals are most resistant to high temperature oxidation. Contrasting with these are the chemically reactive base metals. The alkali metals such as lithium, sodium, potassium are soft, low melting and rapidly oxidizing. The alkali earth metals such as calcium, strontium and radium are employed principally in the form of compounds.

The rare-earth metals are the elements such as cerium and lutetium. There is a group of transition metals such as scandium, nickel, palladium and some others. The refractory metals, possessing high melting points, have received increasing attention of late in connection with their use in turbines, jet and high-speed aircraft. They are such metals as tungsten, molybdenum, tantalum and niobium. Tungsten has a melting point of 3387° C. At the other extreme the low melting metals (rubidium, cesium and mercury) melt just above room temperature, and mercury melts at — 38.87° C. Many elements are classed as semimetals (arsenic, antimony and bismuth, for example) because they possess much poorer conductivities than the true metals and may be classed with the semiconductors, which differ from metals in that their conductivity increases with increasing temperature.

Metallurgist hold different points of view referring metals to different groups and real fundamental understanding of many of the properties of metals still calls for intensive research work.

Nonmetals in the solid state are usually brittle materials without metallic lustre and are usually poor conductors of heat and electricity. In some other physical properties nonmetals have extreme range: in melting point from helium (269º C) to carbon (above 3500º C), and in hardness from diamond to soft white phosphorus. Nonmetals show an even greater variety of chemical properties than do the metals. Some (argon, helium, neon) form no compounds at all, while others (chlorine, fluorine) are highly active. Metals far outnumber the nonmetals, only 20 of all the known elements being considered definitely nonmetals.

TASK 3. Match the following words and word combinations with their English equivalents.

1.	быть измененным	A	catastrophic failure
2.	различие	B	conductivity
3.	прочность	C	luster
4.	катастрофическое последствие	D	capability of withstanding limited overloading
5.	электропроводность	E	rupture
6.	неравномерный	F	alkali metal
7.	огнеупорный металл	G	distinction
8.	способность выдерживать определенную перегрузку	H	to forge
9.	твердость	I	to be altered
10.	разрыв	G	plasticity
11.	блеск	K	strength
12.	щелочной металл	L	intricate shape
13.	сложная форма	M	to weigh
14.	ковать	N	to be weldable
15.	быть свариваемыми	O	constituents
16.	составляющие	P	hardness
17.	благородный металл	Q	refractory metal
18.	весить	R	uneven
19.	пластичность	S	noble metal

TASK 4. Define what parts of speech the words in bold belong to. Translate these word combinations.

Electrical and thermal **conductivity**; **to conduct** electric current; **a conductor** of electricity; **a semiconductor** device; **the conductivity** of electrons; good **conductance**; **conducting** capacity; technical progress; highly skilful technician; modern technique.
In the course of **smelting** activity; the **smelted** iron ore.
Cooper has been **smelted** for many thousand years.
We can use **a hammer**.
Hammering is a very important process.
The **hammered** sword is the best one.

TASK 5. Work in small groups. Discuss advantages and disadvantages of increasing demand for metals.

TEXT B. Metals in perspective

TASK 1. Give Russian equivalents to the following words and word combinations:

to consist of; pure chemical elements; alloys; to combine with; property; wood; stone; ore impurity; that is why; at all.

TASK 2. Read the passage to get a general idea of what metals are.

It is known that metals are very important in our life. Metals have the greatest importance for industry. All machines and other engineering constructions have metal parts; some of them consist only of metal parts. There are two large groups of metals:

1) Simple metals — more or less pure chemical elements.

2) Alloys — materials consisting of a simple metal combined with some other elements.

About two thirds of all elements, found in the earth are metals, but not all metals may be used in industry. Those metals which are used in industry are called engineering metals. The most important engineering metal is iron (Fe) which in the form of alloys with carbon (C) and other elements finds greater use than any other metal. Metals consisting of iron combined with some other elements are known as ferrous metals; all the other metals are called nonferrous metals. The most important nonferrous metals are copper (Cu), aluminum (Al), lead (Pb), zinc (Zn), tin (Sn), but all these metals are used much less than ferrous metals, because the ferrous metals are much cheaper.

If we take all the metal produced by the world' s metallurgical industry during one year for 100 per cent, we shall see that the production of ferrous metals is about 94 per cent, the production of copper is about 2 per cent, zinc about 1.52 per cent, aluminum about 0.6-per cent, etc.

Engineering metals are used in industry in the form of alloys because the properties of alloys are much better than the properties of pure metals. Only aluminum may be largely used in the form of a simple metal.

People began to use metals after wood and stone, but now metals are more important for our industry than these two old materials. Metals have such a great importance because of their useful properties. Metals are much stronger and harder than wood and that is why some engineering constructions and machines were impossible when people did not know how to produce and how to use metals. Metal is not so brittle as stone, which was the first engineering material for people. Strength, hardness, and plasticity of metals are the properties, which made metals so useful for industry. It is possible to find some very, plastic wood, but it will be much softer than many metals; stone may be very hard, but it is not plastic at all. Only metals have a combination of these three most useful engineering properties.

But it is much more difficult to get the metals from the earth in which they are found than to find some stone or wood, that is why people began to use metals after stone and wood. The first metal which was produced by the people, was copper, iron was produced much later.

Different metals are produced in different ways, but almost all the metals are found in the form of metal ore (iron ore, copper ore, etc.).

The ore is a mineral consisting of a metal combined with some impurities. In order to produce a metal from some metal ore, we must separate these impurities from the metal; that is done by metallurgy.

TASK 3. Match the following words and word combinations in column A with their Russian equivalents in column B.

A		B	
1.	standard of living	A	твердый материал
2.	to survive in competition	B	тепловая обработка
3.	skilful use of tools	C	трансформировать свойства
4.	characteristics of strength	D	основные составляющие металлургического процесса
5.	vital importance	E	закаленное железо
6.	in the pure state	F	обжиговая печь в гончарной мастерской
7.	in sufficient quantity	G	выжить в конкурентной борьбе
8.	pottery kiln	H	жизненно важное значение
9.	workable metal	I	в достаточном количестве
10.	process increased the carbon content	G	условия жизни
11.	hard material	K	в чистом состоянии
12.	superior to any other	L	превосходящий любые другие
13.	”quenched” iron	M	умелое использование орудий труда
14.	heat treatment	N	характеристика прочности
15.	to modify properties	O	пригодный для обработки металл
16.	basic metallurgical arts	P	процесс увеличения содержания углерода

TASK 4. Answer the following questions.

1. Which metal is the most important for industry?
2. What is an alloy?
3. Can all metals be used in industry?
4. How do we call alloys consisting of iron combined with carbon?

5. Why are ferrous metals used more largely than nonferrous?
6. What properties of metals make them so useful in engineering?
7. Why cannot wood and stone be so largely used in industry as metals?

TASK 5. Translate into English using the text.

1. Самым важным из технических металлов является железо.
2. Железо используется в промышленности в форме сплава с углеродом.
3. Чистое железо не может быть использовано в промышленности потому, что оно очень мягкое.
4. Наиболее полезными техническими свойствами металлов являются твердость, прочность и пластичность.
5. Дерево – мягче металла, а камень – более хрупок, чем металл.

TEXT C. Metallurgy

TASK 1. Guess the meanings of the following words and word combinations. Compare your translations with the definitions given in the dictionary.

Engineering construction; engineering metal; simple metal; iron(Fe);carbon(C); ferrous metals; nonferrous metals; copper (Cu); aluminum (Al); lead (Pb); zinc (Zn); tin (Sn); to separate

TASK 2. Choose the most suitable heading from the list 1-5 for each paragraph of the text.

Metallurgy is the science of extracting metals from their ores, refining and working them, mechanically or otherwise, to adapt them to use. It is also concerned with the properties of metals, their atomic and crystalline structure, the principles of combining them to form alloys, the means for improvement or enhancing their properties for particular applications, and the relations between properties, structures, and uses. Further, it includes the thermal and mechanical processing of metals as materials of manufacture.	1. Metallurgy is not the science. It is a trade. 2. Metals in a human life 3. The main tasks of metallurgy 4. What is metallurgy concerned with as a science? 5. Metallurgy is the science of extracting metals from their ores.
An essential step towards the Metal Age was the discovery that metals could be melted and cast to shape in molds; another was the discovery that metals could be recovered from metal-bearing minerals. There was a close relationship between these metallurgical developments and the growth of civilization. Man needed a stronger metal than native copper. Metallurgy as a science is relatively new, metals having been subjected to scientific study for less than a century. Since the 19^{th} century, more and more attention has been devoted to a scientific understanding of the properties and structure of metals.	1. Civilization and metallurgy 2. Metal Age 3. Some facts from the history of metallurgy 4. History of humankind 5. Metallurgy as a new science

Metallurgy is a particular broad subject, its scope overlapping many other sciences and technologies, such as physics, chemistry, mining, mechanical and chemical engineering, economics, and manufacturing. Most of the chemical elements are metals, and the metallurgist is interested in the properties and reactions of these metallic elements. Physics also makes many contributions to metallurgy. Since all metallic behaviour is closely associated with the nature of individual atoms and their interactions, atomic theory is of great importance in the study of metals. Nuclear reactions have already become a part of metallurgy. Engineering subjects also contribute to metallurgical practice.	1. Nuclear reactions are not used in metallurgy. 2. Chemistry is the most important part of metallurgy. 3. Physics is the most important part of metallurgy. 4. Metallurgy and other different sciences 5. Metallurgy is an independent science.

TASK 3. Translate the following words formed from adjectives using the dictionary.

Brittle – brittleness – to embrittle; ductile – ductility; smooth – to smooth; hard – hardness – to harden – to caseharden – casehardening – hardening; soft – to soften – softness; cheap – cheapness; important – unimportant – importance; pure – purity – impurity – to purify – purification; strong – strength – to strengthen; plastic – plasticity; hot – heat - to heat; slow – slowly – to slow; solid – to solidify – solidification; tough – toughness – to toughen; expensive – expensiveness.

TASK 4. Complete the sentences and translate them.

1. Most of the chemical elements …
2. Physics also makes many contributions to …
3. Metallurgy is the science of ...
4. Engineering subjects also contribute to …
5. Nuclear reactions have already become …

TASK 5. Make up 5 yes-no questions and 5 questions with a question word. Discuss them with your partner.

TEXT D. Non-ferrous metals

TASK 1. Answer the following questions.

1. What is a non-ferrous metal?
2. Why are non-ferrous metals so widely valued?

TASK 2. Scan the article and see if your guesses were correct.

In metallurgy, a non-ferrous metal is a metal, including alloys, that does not contain iron (ferrite) in appreciable amounts.

Non-ferrous metals were the first metals used by humans for metallurgy. Gold, silver and copper existed in their native crystalline yet metallic form. These crystals, though rare, are enough to attract the attention of humans. Less susceptible to oxygen than most other metals, they can be found even in weathered outcroppings. Copper was the first metal to be forged; it was soft enough to be fashioned into various objects by cold forging and could be melted in a crucible. Gold, silver and copper replaced some of the functions of other resources, such as wood and stone, owing to their ability to be shaped into various forms for different uses. Due to their rarity, these gold, silver and copper artifacts were treated as luxury items and handled with great care.The use of copper also heralded the transition from the Stone Age to the Copper Age. The Bronze Age, which succeeded the Copper Age, was again heralded by the invention of bronze, an alloy of copper with the non-ferrous metal tin.

Generally more costly than ferrous metals are used because of desirable properties such as low weight (e.g. aluminium), higher conductivity (e.g. copper), non-magnetic property or resistance to corrosion (e.g. zinc). Some non-ferrous materials are also used in the iron and steel industries. For example, bauxite is used as flux for blast furnaces, while others such as wolframite, pyrolusite and chromite are used in making ferrous alloys.

Important non-ferrous metals include aluminium, copper, lead, nickel, tin, titanium and zinc, and alloys such as brass. Precious metals such as gold, silver and platinum and exotic or rare metals such as cobalt, mercury, tungsten, beryllium, bismuth, cerium, cadmium, niobium, indium, gallium, germanium, lithium, selenium, tantalum, tellurium, vanadium, and zirconium are also non-ferrous. They are usually obtained through minerals such as sulfides, carbonates, and silicates. Non-ferrous metals are usually refined through electrolysis. It is used in residential, commercial, industrial industry. Material selection for a mechanical or structural application requires some important considerations, including how easily the material can be shaped into a finished part and how its properties can be either intentionally or inadvertently altered in the process. Depending on the end use, metals can be simply cast into the finished part, or cast into an intermediate form, such as an ingot, then worked, or wrought, by rolling, forging, extruding, or other deformation process. Although the same operations are used with ferrous as well as nonferrous metals and alloys, the reaction of nonferrous metals to these forming processes is often more severe. Consequently, properties may differ considerably between the cast and wrought forms of the same metal or alloy.

TASK 3. Find the English equivalents for the words and word combinations given below. Use them in the sentences of your own.

Цветные металлы; содержать железо; электролиз; электрообмотка; предотвратить коррозию; сплав; ржаветь.

TASK 4. Are these sentences true or false according to the text?

1. The cast and wrought forms of the same metal or alloy have the same properties.
2. Depending on the end use, metals can be simply cast into the finished part, or cast into an intermediate form.
3. Precious metals are obtained through minerals.
4. Non-ferrous metals are not refined through electrolysis.
5. Most copper is extracted from sulfides.

TASK 5. Discuss in groups what you have learnt about non-ferrous metals.

TEXT E. Copper

TASK 1. What do you know about copper? Compare your answers with your partner's ones.

TASK 2. Read the text and find out if you were right.

Pure copper is a salmon-pink, rather soft, very malleable and ductile metal. Upon exposure to air, copper acquires a brown coating of oxide and sulphide, this, however, protects it from further corrosion. To prevent the loss of the shiny appearance of copper and brass these metals are sometimes lacquered, i.e. coated with a transparent coating of shellac. The so-called "oxidized copper" is really copper coated with copper sulphide made by immersing the metal in a solution of ammonium polysulphide.

Copper was used in prehistoric times for making weapons and tools and later was alloyed with tin to form bronze, which was the most important metal of the Greeks and Romans. It was replaced for these purposes by iron and steel. Various grades of copper are used for engineering purposes. The great development of the electric industries has resulted in such extensive uses of the metal that it now ranks next to iron in importance.

It is a good conductor and it is surpassed only by silver for conductivity of electricity and the making of electrical apparatus is the chief use for copper, *e. g.* telephone and telegraph cables; electric wiring; parts of dynamos and electric motors. Three important copper alloys are brass, bronze, and cupro-nickel (75% copper + 25% nickel) which is used for the present "silver" coins.

Copper oxide is a black, hygroscopic basic oxide. It may be made by heating copper nitrate, carbonate or hydroxide. It is reduced to a pink residue of copper by being heated in hydrogen, carbon monoxide or ammonia. It is used in the manufacture of blue glass.

Copper sulphate, blue vitriol, $CuSO_4 \cdot 5H_2O$, is used in the laboratory for detecting the presence of water; it is used in horticulture for killing fungi. For this purpose, Bordeaux mixture, a spray made by dissolving equal weights of copper sulphate and quicklime in water, is used.

Copper nitrate is readily prepared by dissolving copper in nitric acid. It offers a means of preparing those copper compounds (copper oxide, sulphate and chloride) which are not capable of being directly prepared from copper. Smelted copper was rarely pure, in fact, it is clear that by 2500 BC the Sumerians had recognized that if different ores were blended together in the smelting process, a different type of copper, which flowed more easily, was stronger after forming and was easy to cast, could be made. An axe head from 2500 BC revealed that it contained 11% tin and 89% copper. This was of course the discovery of bronze. However, by 2000 BC copper implements contained very little tin as local reserves of tin had been exhausted. The Sumerians were forced to travel to find the necessary ores. Bronze was a much more useful alloy than copper as farm implements and weapons could be made from it, however, it needed the discovery of tin to become the alloy of choice.

TASK 3. Answer the following questions.

1. What does pure copper look like?
2. What happens when copper is exposed to air?
3. Why is copper sometimes coated with shellac?
4. What do you know about the method of copper sulphide making?
5. For what purposes was copper used in prehistoric times?
6. What was copper replaced by for these purposes later on?
7. Why is copper widely used nowadays?
8. What are the most important copper alloys?
9. How is copper oxide made?
10. What fields is copper oxide used in?
11. Where is copper sulphide used?
12. How can we prepare copper nitrate?

TASK 4. Tell your fellow-students about the uses of copper.

TASK 5. Describe the things made of copper (or its alloys) that you have at home.

TEXT F. Tin

TASK 1. What do you know about tin? Compare your answers with your partner's ones.

TASK 2. Read the text and find out if you were right.

Tin is a chemical element with the symbol Sn (from Latin: stannum) and atomic number 50. It is a post-transition metal in group 14 of the periodic table of elements. It is obtained chiefly from the mineral cassiterite, which contains stannic oxide, SnO2. Tin shows a chemical similarity to both of its neighbors in group 14, germanium and lead, and has two main oxidation states, +2 and the slightly more stable +4. Tin is the 49th most abundant element and has, with 10 stable isotopes, the largest number of stable isotopes in the periodic table, thanks to its magic number of protons. It has two main allotropes: at room temperature, the stable allotrope is β-tin, a silvery-white, malleable metal, but at low temperatures it transforms into the less dense grey α-tin, which has the diamond cubic structure. Metallic tin does not easily oxidize in air.

The first tin alloy used on a large scale was bronze, made of tin and copper, from as early as 3000 BC. After 600 BC, pure metallic tin was produced. Pewter, which is an alloy of 85–90% tin with the remainder commonly consisting of copper, antimony, and lead, was used for flatware from the Bronze Age until the 20th century. In modern times, tin is used in many alloys, most notably tin/lead soft solders, which are typically 60% or more tin and in the manufacture of transparent, electrically conducting films of indium tin oxide in optoelectronic applications. Another large application for tin is corrosion-resistant tin plating of steel. Because of the low toxicity of inorganic tin, tin-plated steel is widely used for food packaging as tin cans. However, some organotin compounds can be almost as toxic as cyanide.

Native Tin is not found in nature. The first tin artifacts date back to 2000 BC, however, it was not until 1800 B.C. that tin smelting became common in western Asia. Tin was reduced by charcoal and at first was thought to be a form of lead. The Romans referred to both tin and lead as plumbum where lead was plumbum nigrum and tin was plumbum candidum. Tin was rarely used on its own and was most commonly alloyed to copper to form bronze. The most common form of tin ore is the oxide casserite. By 1400 BC bronze was the predominant metal alloy

Tin is highly malleable and ductile, highly crystalline and during deformation is subject to mechanical twinning. Tin is also quite resistant to corrosion.

Tin is found as vein tin or stream tin. The tin ore is stannic oxide and is generally found with quartz, feldspar or mica. The ore is a hard, heavy and inert substance and is generally found as outcroppings as softer impurities are washed away.

TASK 3. Answer the following questions.

1. What is the most tin extracted from?
2. Why is tin so widely valued?
3. Was tin widely known in Roman times?
4. What are the properties of tin?
5. Why is tin widely used for coating other metals?

TASK 4. Think of more questions you might ask about.

TASK 5. Speak about the development of tin use.

TEXT G. Precious metals

TASK 1. Find the English equivalents for the words and word combinations given below. Find them in the text.

Имитация золота; драгоценные металлы; ювелирное украшение; окисляться; терять блеск; серебро высшей пробы; серебряные копи; химическая промышленность.

TASK 2. Read and translate the following text.

The precious metals include: ruthenium, rhodium, palladium, silver, osmium, iridium, gold, and platinum. Their precious nature derives from the fact they are very scarce and unique among commodities and they are judged as a measure of wealth

Precious metals have important physical characteristics which make them indispensable to modern industry. For example: one cubic centimeter of palladium is capable of absorbing 900cc of hydrogen; silver has the highest electrical conductivity of any metal; gold is the most ductile metal; iridium is the most corrosion resistant of all elements; osmium is the heaviest metal; and the platinum group, in general, contains the hardest metals. But the most widely used and well-known precious metals are gold and silver.

The supply and demand laws in the gold market are highly dependent upon gold's role as a medium of exchange. Decorative uses account for about sixty percent of demand, owing partly to gold's unique physical properties and partly to its interchangeability with money. Gold is also used as decoration. When used in industry, it is almost invariably alloyed with other less expensive metals, such as copper, zinc, silver and nickel. Important commercial uses include wiring in electronics, semiconductors in tiny computer chips. Dental work also accounts for significant gold consumption.

The primary use of silver is in jewelry, cutlery and art objects. It is often alloyed with copper. Silver is much more sought than gold, however, in industrial usage. It is used as photographic materials and in computers, switchgear, thermostats, and other industrial uses. The latter includes use in solders, brazing alloys, catalyst, batteries and pharmaceutical products.

TASK 3. Metals are shaped by the processes such as: casting, forging, rolling, laser cladding, extrusion, sintering, machining, fabrication and others. Match the process with its correct description.

Casting	A hot and malleable metal is forced under pressure through a die, which shapes it before it cools.
Forging	A powdered metal is heated in a non-oxidizing environment after being compressed into a die.

Rolling	Sheets of metal are cut with guillotines or gas cutters and bent and welded into structural shape.
Laser cladding	A red-hot billet is hammered into shape.
Extrusion	Metallic powder is blown through a movable laser beam. The resulting melted metal reach a substrate to form a melt pool. By moving the laser head, it is possible to stack the tracks and build up a 3D piece.
Sintering	A billet is passed through successively narrower rollers to create a sheet.
Machining	Molten metal is poured into a shaped mold.
Fabrication	Lathes, milling machines, and drills cut the cold metal to shape.

TASK 4. Answer the following questions.

1. Why are the precious metals valued for?
2. Why is it easy to hammer gold into thin sheets?
3. Where is gold used?
4. What are the properties of silver?

TASK 5. What is the difference between the precious metals and non-metals?

TEXT H. Rare-earth metals

TASK 1. What do you know about a rare-earth metal? Compare your answers with your partner's ones.

TASK 2. Read the text and pay attention to the words in bolds. Find in the dictionary their correct pronunciation and meaning.

A rare-earth element (REE) or rare-earth metal (REM), as defined by IUPAC, is one of a set of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides, as well as scandium and yttrium. Scandium and yttrium are considered rare-earth elements because they tend to occur in the same ore **deposits** as the lanthanides and exhibit similar chemical properties. For the same set of mineralogical, chemical, physical (especially electron shell configuration), and related reasons, a broader definition of rare earth elements including the **actinides** is encountered in some cases. Thorium is a significant component of monazite and other important rare earth minerals, and **uranium** and **decay products** are found in others. Both series of elements begin on the periodic table in group 3 under yttrium and scandium.

The 17 rare-earth elements are cerium (Ce), dysprosium (Dy), erbium (Er), europium (Eu), gadolinium (Gd), holmium (Ho), lanthanum (La), lutetium (Lu), neodymium (Nd), praseodymium (Pr), promethium (Pm), samarium (Sm), scandium (Sc), terbium (Tb), thulium (Tm), ytterbium (Yb), and yttrium (Y).

Despite their name, rare-earth elements are – with the **exception** of the radioactive promethium – relatively plentiful in Earth's crust, with cerium being the 25th most abundant element at 68 parts per million, more **abundant** than copper. They are not especially **rare**, but they tend to **occur** together in nature and are difficult to separate from one another. However, because of their geochemical properties, rare-earth elements are typically dispersed and not often found concentrated as rare-earth minerals in economically exploitable ore deposits. The first such mineral discovered (1787) was gadolinite, a mineral composed of cerium, yttrium, iron, silicon, and other elements. This mineral was **extracted** from a mine in the village of Ytterby in Sweden; four of the rare-earth elements bear names derived from this single location.

TASK 3. Work in pairs. Imagine that you are starting a presentation. What phrases might you use? After you've thought, look below for some more ideas.

Useful Phrases:

Ladies and gentlemen, thank you very much for coming along here today.
The purpose of today's presentation is to discuss how we can…
I've invited you here today to have a look at my findings.
Now let me begin by…
Secondly…
…and finally…
I'd be happy to invite you to ask questions at the end of the session.

At the end I'd be very happy to answer any of your questions.

TASK 4. Imagine it is the end of your presentation and you are asking if there are any questions. What phrases might you use or hear? Look below for some more ideas.

Useful Phrases:
If you have any questions, I would be happy to answer them now.
Can I just ask…?
Are there any questions about any of that?
Yes, it's a very good question.
Can you explain to me…?

TASK 5. Make your own presentation about rare-earth metals.

UNIT II NONFERROUS METALS PRODUCTION

TEXT A. Non-ferrous extractive metallurgy

TASK 1. Give the Russian equivalents to the following words and words combinations.

Extractive metallurgy; marketable metals; target metals; rare and noble metals; extraction process; to reduce; chemical processes.

TASK 2. Read the text. Sum up each paragraph in two sentences.

Non-ferrous extractive metallurgy is one of the two branches of extractive metallurgy which pertains to the processes of reducing valuable, non-iron metals from ores or raw material. Metals like zinc, copper, lead, aluminium as well as rare and noble metals are of particular interest in this field, while the more common metal, iron, is considered a major impurity. Like ferrous extraction, non-ferrous extraction primarily focuses on the economic optimization of extraction processes in separating qualitatively and quantitatively marketable metals from its impurities (gangue).

Any extraction process will include a sequence of steps or unit processes for separating highly pure metals from undesirables in an economically efficient system. Unit processes are usually broken down into three categories: pyrometallurgy, hydrometallurgy, and electrometallurgy. In pyrometallurgy, the metal ore is first oxidized through roasting or smelting. The target metal is further refined at high temperatures and reduced to its pure form. In hydrometallurgy, the object metal is first dissociated from other materials using a chemical reaction, which is then extracted in pure form using electrolysis or precipitation. Finally, electrometallurgy generally involves electrolytic or electrothermal processing. The metal ore is either distilled in a electrolyte or acid solution, then magnetically deposited onto a cathode plate (electrowinning); or smelted then melted using an electric arc or plasma arc furnace (electrothermic reactor). Extractive metallurgy of ferrous and non-ferrous metals can involve pyrometallurgy, but chemical processes like hydrometallurgy and electrometallurgy are far more common in method of non-ferrous extraction.

Another major difference in non-ferrous extraction is the greater emphasis on minimizing metal losses in slag. This is widely due to the exceptional scarcity and economic value of certain non-ferrous metals which are, inevitably, discarded during the extraction process to some extent. Thus, material resource scarcity and shortages are of great concern to the non-ferrous industry. Recent developments in non-ferrous extractive metallurgy now emphasize the reprocessing and recycling of rare and non-ferrous metals from secondary raw materials (scrap) found in landfills.

TASK 3. Are these sentences true or false according to the text?

1. Electrometallurgy generally involves electrolytic processing.
2. Pyrometallurgy is an extractive metallurgy of ferrous and non-ferrous metals.
3. Extractive metallurgy follows the processes of reducing valuable, non-iron metals from ores or raw material.

TEXT B. Prehistory of non-ferrous extractive metallurgy

TASK 1. Give the Russian equivalents to the following words and words combinations:

prehistoric extraction; melting; available technology; smelting temperatures; pyrometallurgical extraction

TASK 2. Read the text. For each of the paragraphs choose the best headings from the list and write its letter beside the paragraph.

A. Medieval smelting plant
B. Hydrometallurgy in Chinese antiquity
C. Prehistoric extraction of metals

____In general, prehistoric extraction of metals, particularly copper, involved two fundamental stages: first, the smelting of copper ore at temperatures exceeding 700 °C is needed to separate the gangue from the copper; second, melting the copper, which requires temperatures exceeding its melting point of 1080 °C. Given the available technology at the time, accomplishing these extreme temperatures posed a significant challenge. Early smelters developed ways to effectively increase smelting temperatures by feeding the fire with forced flows of oxygen.

Copper extraction in particular is of great interest in archeometallurgical studies since it dominated other metals in Mesopotamia from the early Chalcolithic until the mid-to-late sixth century BC. There is a lack of consensus among archaeometallurgists on the origin of non-ferrous extractive metallurgy. Some scholars believe that extractive metallurgy may have been simultaneously or independently discovered in several parts of the world. The earliest known use of pyrometallurgical extraction of copper occurred in Belovode, eastern Serbia, from the late sixth to early fifth millennium BC. However, there is also evidence of copper smelting in Tal-i-Iblis, southeastern Iran, which dates back to around the same period. During this period, copper smelters used large in-grown pits filled with coal, or crucibles to extract copper, but by the fourth millennium BC this practice had begun to phase out in favor of the smelting furnace, which had a larger production capacity. From the third millennium onward, the invention of the reusable smelting furnace was crucial to the success of large-scale copper production and the robust expansion of the copper trade through the Bronze Age.

The earliest silver objects began appearing in the late fourth millennium BC in Anatolia, Turkey. Prehistoric silver extraction is strongly associated with the extraction of the less valuable metal, lead; although evidence of lead extraction technology predates silver by at least 3 millennia. Silver and lead extractions are also associated because the argentiferous (silver-bearing) ores used in the process often contains both elements.

In general, prehistoric silver recovery was broken down into three phases: First, the silver-lead ore is roasted to separate the silver and lead from the gangue. The metals are then melted at high temperature in the crucible while air is blown over the molten metal (cupellation). Finally, lead is oxidized to form lead monoxide (PbO) or is absorbed into the walls of the crucible, leaving the refined silver behind.

The silver-lead cupellation method was first used in Mesopotamia between 4000 and 3500 BC. Silver artifacts, dating around 3600 BC, were discovered in Naqada, Egypt. Some of these cast silver artifacts contained less than 0.5% lead, which strongly indicates cupellation.

_____Cupellation was also being used in parts of Europe to extract gold, silver, zinc, and tin by the late ninth to tenth century AD. Here, one of the earliest examples of an integrated unit process for extracting more than one precious metal was first introduced by Theophilus around the twelfth century. First, the gold-silver ore is melted down in the crucible, but with an excess amount of lead. The intense heat then oxidizes the lead which reacts quickly and binds with the impurities in the gold-silver ore. Since both gold and silver have low reactivity with the impurities, they remain behind once the slag is removed. The last stage involves parting, in which the silver is separated from the gold. First the gold-silver alloy is hammered into thin sheets and placed into a vessel. The sheets were then covered in urine, which contains sodium chloride (NaCl). The vessel is then capped and heated for several hours until the chlorides bind with the silver, creating silver chloride (AgCl). Finally, the silver chloride powder is then removed and smelted to recover the silver, while the pure gold remains intact.

_____ During the Song Dynasty, Chinese copper output from domestic mining was in decline and the resulting shortages caused miners to seek alternative methods for extracting copper. The discovery of a new “wet process” for extracting copper from mine water was introduced between the eleventh and twelfth century, which helped to mitigate their loss of supply.

Similar to the Anglo-Saxon method for cupellation, the Chinese employed the use of a base metal to extract the target metal from its impurities. First, the base metal, iron, is hammered into thin sheets. The sheets are then placed into a trough filled with “vitriol water” i.e., copper mining water which is then left to steep for several days. The mining water contains copper salts in the form of copper sulfate $CuSO_4$. The iron then reacts with the copper, displacing it from the sulfate ions, causing the copper to precipitate onto the iron sheets, forming a "wet" powder. Finally, the precipitated copper is collected and refined further through the traditional smelting process. This is the first large-scale use of a hydrometallurgical process.

TASK 3. Are these sentences true or false according to the text?

1. Similar to the Anglo-Saxon method for cupellation, the Chinese didn’t employ the use of a base metal to extract the target metal from its impurities.

2. Silver and lead extractions are also associated because the argentiferous (silver-bearing) ores used in the process often contains both elements.

3. Copper extraction in particular is of great interest in archeometallurgical studies since it dominated other metals in Mesopotamia from the early Chalcolithic until the mid-to-late seventh century BC.

TEXT C. What is Nonferrous Metals Manufacturing?

TASK 1. Give the Russian equivalents to the following words and words combinations.

To deal with; scrap metals; to heat; recycled metals; smelter furnace; ore mixtures; main ingredients.

TASK 2. Read and translate the text.

The non-ferrous manufacturing industry deals with the production and transformation of metals that do not contain iron as a main ingredient, such as copper, aluminium, zinc, tin, nickel, lithium, precious metals, and minor metals. Primary metals manufacturers extract metals from ores and operate smelters, which heat ore mixtures to separate liquid metal and impurities. Secondary manufacturers process recycled or scrap metals. Extraction processes include chemical addition (e.g. limestone, coke, soda ash) and treatments (e.g. solvents). Some processes involve application of electrical current (e.g., aluminum, tin). The metals may be cast into various shapes (e.g., billets, ingots, bars) prior to shipment to customers, which fabricate final products.

The wastewater streams generated by the industry vary according to the metal extraction processes employed, but generally derive from smelter furnace and filtration residues, rinsing of materials, spent solutions, equipment cooling and air pollution controls (wet scrubbers).

TASK 3. Are these sentences true or false according to the text?

1. Non-ferrous metals are based on iron.
2. The non-ferrous manufacturing industry deals with the production and transformation of nonmetals.
3. Electrical current is never used in the non-ferrous manufacturing industry.

TEXT D. Electrolysis

TASK 1. Give the Russian equivalents to the following words and words combinations.

An electrolytic cell; decomposition; chemical reactions; interchange of atoms and ions; voltage; electric current; electrodes.

TASK 2. Read the text. For each of the paragraphs choose the best headings from the list and write its letter beside the paragraph.

A. Energy changes during electrolysis
B. The main components
C. Oxidation and reduction at the electrodes
D. Process of electrolysis

_____In chemistry and manufacturing, electrolysis is a technique that uses a direct electric current (DC) to drive an otherwise non-spontaneous chemical reaction. Electrolysis is commercially important as a stage in the separation of elements from naturally occurring sources such as ores using an electrolytic cell. The voltage that is needed for electrolysis to occur is called the decomposition potential.

Electrolysis is the passing of a direct electric current through an ionic substance that is either molten or dissolved in a suitable solvent, producing chemical reactions at the electrodes and a separation of the materials.

The main components required to achieve electrolysis are:

- An electrolyte: a substance, frequently an ion-conducting polymer that contains free ions, which carry electric current in the electrolyte. If the ions are not mobile, as in most solid salts, then electrolysis cannot occur.
- A direct current (DC) electrical supply: provides the energy necessary to create or discharge the ions in the electrolyte. Electric current is carried by electrons in the external circuit.
- Two electrodes: electrical conductors that provide the physical interface between the electrolyte and the electrical circuit that provides the energy.

Electrodes of metal, graphite and semiconductor material are widely used. Choice of suitable electrode depends on chemical reactivity between the electrode and electrolyte and manufacturing cost.

____The key process of electrolysis is the interchange of atoms and ions by the removal or addition of electrons from the external circuit. The desired products of electrolysis are often in a different physical state from the electrolyte and can be removed by some physical processes. For example, in the electrolysis of brine to produce hydrogen and chlorine, the products are gaseous. These gaseous products bubble from the electrolyte and are collected.

$$2\ NaCl + 2\ H_2O \rightarrow 2\ NaOH + H_2 + Cl_2$$

A liquid containing electrolyte is produced by:

- Solvation or reaction of an ionic compound with a solvent (such as water) to produce mobile ions
- An ionic compound is melted by heating

An electrical potential is applied across a pair of electrodes immersed in the electrolyte.

Each electrode attracts ions that are of the opposite charge. Positively charged ions (cations) move towards the electron-providing (negative) cathode. Negatively charged ions (anions) move towards the electron-extracting (positive) anode.

In this process electrons are either absorbed or released. Neutral atoms gain or lose electrons and become charged ions that then pass into the electrolyte. The formation of uncharged atoms from ions is called discharging. When an ion gains or loses enough electrons to become uncharged (neutral) atoms, the newly formed atoms separate from the electrolyte. Positive metal ions like Cu^{++} deposit onto the cathode in a layer. The terms for this are electroplating, electrowinning, and electrorefining. When an ion gains or loses electrons without becoming neutral, its electronic charge is altered in the process. In chemistry, the loss of electrons is called Oxidation, while electron gain is called reduction.

_________Oxidation of ions or neutral molecules occurs at the anode. For example, it is possible to oxidize ferrous ions to ferric ions at the anode:

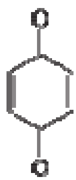
$Fe^{2+} (aq) \rightarrow Fe^{3+} (aq) + e^-$

Reduction of ions or neutral molecules occurs at the cathode.

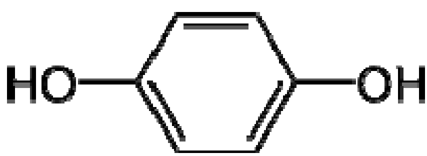
It is possible to reduce ferricyanide ions to ferrocyanide ions at the cathode:

$Fe(CN)_6^{3-} + e^- \rightarrow Fe(CN)_6^{4-}$

Neutral molecules can also react at either of the electrodes. For example: p-Benzoquinone can be reduced to hydroquinone at the cathode:



$+ 2 e^- + 2 H^+ \rightarrow$



In the last example, H+ ions (hydrogen ions) also take part in the reaction, and are provided by an acid in the solution, or by the solvent itself (water, methanol etc.). Electrolysis reactions involving H+ ions are fairly common in acidic solutions. In aqueous alkaline solutions, reactions involving OH− (hydroxide ions) are common.

Sometimes the solvents themselves (usually water) are oxidized or reduced at the electrodes. It is even possible to have electrolysis involving gases. Such as when using a Gas diffusion electrode.

________The amount of electrical energy that must be added equals the change in Gibbs free energy of the reaction plus the losses in the system. The losses can (in theory) be arbitrarily close to zero, so the maximum thermodynamic efficiency equals the enthalpy change divided by the free energy change of the reaction. In most cases, the electric input is larger than the enthalpy change of the reaction, so some energy is released in the form of heat. In some cases, for instance, in the electrolysis of steam into hydrogen and oxygen at high temperature, the opposite is true and heat energy is absorbed. This heat is absorbed from the surroundings, and the heating value of the produced hydrogen is higher than the electric input.

TASK 3. Translate the text into Russian.

TEXT E. A metallurgical company

TASK 1. Study some new expressions and words. Consult the dictionary if any words are unknown to you:

foundry equipment; productive capacity; casting houses; rolling process; degassing; pouring.

TASK 2. Read and translate the text about French metallurgical company.

The "Pechiney Aluminum Engineering" (PAE) company is a part of the research and engineering center "Pechiney Vorepp" specialized in the field of foundry equipment and serves as the interlink between researchers, factories and process management. The "Pechiney" company improves the manufacturing processes with the help of the PAE company. The equipment and technologies offered by PAE are the most optimum as to the quality of working, productive capacity, carrying charges and operating conditions.

The company directly participates in testing and improvement of the equipment characteristics and processes at all stages of development including researches, construction of the prototype model and its engineering development, improvement of a pilot unit at the factory, adaptation of the technology to the customer's needs and technical assistance in technology development.

The PAE company staff includes 60 people including 15 people working in the research department and 15 high-skilled engineers-experimentalists; each of them possesses the operational experience in casting houses at the factories of the “Pechiney” company.

The company has 250 customers in 60 countries and its annual turnover constitutes 30 million euro, and 90 % of developments are delivered for export.

At present time, the PAE company offers 3 engineering and technology development works tested and approved at the factories of the “Pechiney” company.

- manufacturing process Dzumbo 3S for continuous casting of bands;
- technical assistance in the rolling process improvement;
- foundry equipment for degassing, filtering, and pouring.

Besides, the “Pechiney” company may offer the casting houses made on a turn-key basis to their customers.

TASK 3. Prepare a short presentation about another metallurgical company, which you know. Use the plan given below:

1. an overview of the company
2. a description of the different sectors/business area it operates in
3. staff
4. customers and clients
5. the last company’s offers

APPENDICES

THE LIST OF CHEMICAL ELEMENTS

Ag – argentums [a:´ʤəntəm] =silver - серебро

Al – aluminium [ˏælju´miəm]– алюминий

Ar – argon [´a:rgɔn] –аргон

As-Arsenic [´a:s(ə)nik] – мышьяк

Au-aurum [´ɔ:rəm] =gold [gould]– золото

Ba –boron [´bɔ:rɔn – бор

Be – beryllium [´bɛ(ə)riəm – бериллий

Bi-bismuth [´bizməθ] - висмут

Br- bromine [´broumi:n]– бром

C –carbon [´ka:bən]–углерод

Ca- calcium [´kælsiəm]– кальций

Ce- cerium [´si(ə)riəm]– церий

Cd – cadmium [´kædmiəm]– кадмий

Cl – chlorine [´klɔ:ri:n] – хлор

Co – cobalt [´koubɔ:lt] - кобальт

Cr – chromium [´kroumiəm]– хром

Cs – caesium [´si:ziəm] – цезий

Cu –cuprum, copper [´kɔpə] – медь

F - fluorine [´flu(ə)ri:n] – фтор

Fe – ferrum [´ferəm]=iron [´aiən]– железо

Ga – gallium [´gæliəm] –галлий

Ge – germanium [ʤə:´meniəm]– германий

H – hydrogen [´haidrəʤən]– водород

He –helium [´hi:liəm]– гелий

Hg – hydrargyrum [hai´dra:ʤirən]= mercury [´mə:kjuri] – ртуть

I – iodine [´aiədin]– йод

Ir – iridium [i´ridiəm] – иридий

K – kalium [´keiliəm] = potassium[pə´tæsiəm]- калий

Li – lithium [´liθiəm]– литий

Mg – magnesium [mæg´ni:ziəm – магний

Mn – manganese [ˏmæŋgə´ni:z]– марганец

Mo – molybdenum [mə´libdənəm] – молибден

N – nitrogen [´naitrəʤ(ə)n]– азот

Na – natrium [´neitriəm]= sodium [´soudiəm]– натрий

Ne – neon [´ni:ɔn]- неон

Ni – nickel [´nik(ə)l]- никель

O - oxygen [´ɔksiʤ(ə)n]- кислород

P – phosphorus [´fɔsf(ə)rəs]– фосфор

Pl – plumbum [´plʌmbəm]= lead - свинец

Pl – platinum [´plæ´tinəm]– платина

Pu – plutonium[plu:touniəm] – плутоний

Ra – radium [´reidiəm]–радий

Rb –rubidium [ru:´bidiəm]- рубидий

S – sulphur [´sʌlfə]– сера

Sb- antimony [´æntiməni]– сурьма

Sc – scandium [´skændiəm]– скандий

Se – selenium [si´li:niəm]- селен

Si – silicone [´silikoun]– кремний

Sn stannum [´stænəm]= tin [tin] – олово

Sr – strontium [´strɔntiəm]– стронций

Te – tellurium [´təl(j)u(ə)riəm]- теллур

Th – thorium [´θɔ:riəm]– торий

Ti – titanium [t(a)i´teiniəm]- титан

U – uranium [´əm]- уран

W – wolfram [ju´reiniəm]= tungsten

Zn – zinc [´ziŋk]– цинк

Zr –zirconium [zə:´kouniəm]– цирконий

HOW TO READ CHEMICAL FORMULARS AND EQUATIONS

$CH_4+2O_2 \rightarrow CO+2H_2O$
[´si: ´eitʃ ´fɔ: ´plʌs ´tu: ´mɔlikju:lz əv ´ou ´tu: ´givs ´si: ´ou ´plʌs ´tu : ´mɔlikju:lz əv ´eitʃ ´tu: ´ou]
$H^++NaHCO_3 \rightarrow Na^+ +H_2CO_3 \rightarrow Na^++H_2O+CO_2$
[´haidrəʤən´aiən´ plʌs ´en´ei´eitʃ ´si: ´ou ´θri: ´givs ´neitriəm ´aiən ´plʌs ´eitʃ ´tu: ´si: plʌs ´si: ´ou ´tu:]
$4HCl+O_2=2Cl_2+2H_2O$
[´fɔ: ´mɔlikju:lz əv´eitʃ ´si: ´el ´plʌs´ou´tu: ´givs´tu: ´mɔlikju:lz əv ´si: ´el ənd ´tu: ´mɔlikju:lz əv´eitʃ´tu: ´ou]

GLOSSARY

Alchemy - (a) Alchemy was the science (or pseudo-science) of combined disciplines in chemistry, metallurgy, physics, and mysticism with the goal of transforming base metals into precious metals.

Alloy (n) - a combination of two or more elements, at least one of which is a metal, and where the resulting material has metallic properties. 14 carat (58%) gold is an alloy of pure gold (24k) mixed with other elements.

Alluvial Gold - is (a) gold that is found in the soil or sediments deposited by a river, stream, or other running water. (aka Placer of Surface Gold).

Annealing - (v) multi-phased heat and stress treatment that alters the microstructure of a metal adding strength, pliability, and hardness.

Bamboo Grain Structure - is a structure in wire or sheet in which the boundaries of the grains tend to be aligned normal to the long axis and to extend completely through the thickness.

Band Saw Steel (Wood) - a hardened tempered bright polished high carbon cold rolled spring steel strip produced especially for use in the manufacture of band saws for sawing wood, non ferrous metals, and plastics. Usually carries some nickel and with a Rockwell value of approximately-C40/45

Banded Structure - appearance of a metal showing parallel bands in the direction of rolling or working.

Banding - inhomogeneous distribution of alloying elements or phases aligned in filaments or plates parallel to the direction of working.

Bark - is surface of metal, under the oxide-scale layer, resulting from heating in an oxidizing environment. In the case of steel, such bark always suffers from decarburization.

Basic Oxygen Process - a steel making process wherein oxygen of the highest purity is blown onto the surface of a bath of molten iron contained in a basic lined and ladle shaped vessel. The melting cycle duration is extremely short with quality comparable to open hearth steel.

Basic Steel - steel melted in a furnace with a basic bottom and lining and under a slag containing an excess of a basic substance such as magnesia or lime.

Bath Annealing - is immersion in a liquid bath (such as molten lead or fused salts) held at an assigned temperature-when a lead bath is used, the process is known as lead annealing

Bauxite - is the only commercial ore of aluminum, corresponding essentially to the formula Al2O3xH2O.
Bearing Load - a compressive load supported by a member, usually a tube or collar, along a line where contact is made with a pin, rivet, axle, or shaft.
Bend Test - various tests which are used to ascertain the toughness and ductility of a metal product, in which the material is bent around its axis and/ or around an outside radius. A complete test might specify such a bend to be both with and against the direction of grain. For testing, samples should be edge filed to remove burrs and any edgewise cracks resulting from slitting or shearing. If a vice is to be employed, then you must line the jaws with some soft metal, to permit a flow of the metal in the piece being tested.
Beryllium Copper - an alloy of copper and 2-3% beryllium with optionally fractional percentages of nickel or cobalt. Alloys of this series show remarkable age-hardening properties and an ultimate hardness of about 400 Brinell (Rockwell C43). Because of such hardness and good electrical conductivity, beryllium-copper is used in electrical switches, springs, etc.
Bessemer Process - a process for making steel by blowing air through molten pig iron contained in a refractory lined vessel so that the impurities are thus removed by oxidation.
Billet - a solid semi-finished round or square product that has been hot worked by forging, rolling, or extrusion. An iron or steel billet has a minimum width or thickness of 1 1/2 in. and the cross-sectional area varies from 2 1/4 to 36 sq. in. For nonferrous metals, it may also be a casting suitable for finished or semi-finished rolling or for extrusion.
Binary Alloy - an alloy containing two elements, apart from minor impurities, as brass containing the two elements copper and zinc.
Blast Furnace - a vertical shaft type smelting furnace in which an air blast is used, usually hot, for producing pin iron. The furnace is continuous in operation using iron ore, coke, and limestone as raw materials which are charged at the top while the molten iron and slag are collected at the bottom and are tapped out at intervals.

Blister - a defect in metal, on or near the surface, resulting from the expansion of gas in a subsurface zone. Very small blisters are called pinheads or pepper blisters.
Blister Steel - is high-carbon steel produced by carburizing wrought iron. The bar, originally smooth, is covered with small blisters when removed from the cementation (carburizing) furnace.
Bloom - (**1**) Ancient Definition: iron produced in a solid condition directly by the reduction of ore in a primitive furnace. The carbon content is variable but usually low, also known as bloomery iron. It is the earliest iron making process, but still used in underdeveloped countries. (**2**) Modern Definition: a semi-finished hot rolled steel product, rectangular in section, usually produced on a blooming mill but sometimes made by forging.
Bloomery - a primitive furnace used for direct reduction of ore to iron.
Body-Centered - having the equivalent lattice points at the corners of the unit cell, and at its center; sometimes called centered, or space-centered.
Boron (chemical symbol B) - Element N. 5 of the periodic system. Atomic weight is 10.82. It is gray in color, ignites at about 1112 (degrees) F. and burns with a brilliant green flame, but its melting point in a non-oxidizing atmosphere is about 4000 (degrees) F. Boron is used in steel in minute quantities for one purpose only- to increase the harden ability as in case hardening and to increase strength and hardness penetration.
Brittleness - the tendency of a metal or material to fracture without undergoing appreciable plastic deformation.
DC (Direct Chill) Casting - a continuous method of making ingots or billets for sheet or extrusion by pouring the metal into a short mold. The base of the mold is a platform that is gradually lowered while the metal solidifies, the frozen shell of metal acting as a retainer for the liquid metal below the wall of the mold. The ingot is usually cooled by the impingement of water directly on the mold or on the walls of the solid metal as it is lowered. The length of the ingot is limited by the depth to which the platform can be lowered; therefore, it is often called semicontinuous casting.
Casting - an object at or near finished shape obtained by solidification of a substance in a mold. (**2**) Pouring molten metal into a mold to produce an object of desired shape.

Dead Flat - perfectly flat. As pertaining to sheet, strip or plate. Refer to Stretcher Leveling.
Dead Soft Steel - steel, normally made in the basic open-hearth furnace or by the basic oxygen process with carbon less than 0.10% and manganese in the 0.20-0.50% range, completely annealed.
Dead Soft Temper - condition of maximum softness commercially attainable in wire, strip, or sheet metal in the annealed state.
Decarburization - removal of carbon from the outer surface of iron or steel, usually by heating in an oxidizing or reducing atmosphere. Water vapor, oxygen and carbon dioxide are strong decarburizers. Reheating with adhering scale is also strongly decarburizing in action.
Delta Iron - allotropic modification of iron, stable above 2552 (degrees) F. to melting point. It is of body-centered cubic crystal structure.
Deoxidation - (**1**) Removal of oxygen from molten metals by use of suitable chemical agents. (**2**) Sometimes refers to removal of undesirable elements other than oxygen by the introduction of elements or compounds that readily react with them.
Diffusion - (**1**) spreading of a constituent in a gas, liquid or solid, tending to make the composition of all parts uniform. (**2**) The spontaneous movement of atoms or molecules to new sites within a material.
Ductility - the ability of a material to deform plastically without fracturing, being measured by elongation or reduction of area in a tensile test, by height of cupping in an Erichsen test or by other means or the capacity of a material to deform plastically without fracturing.
Casting - an object at or near finished shape obtained by solidification of a substance in a mold. (**2**) Pouring molten metal into a mold to produce an object of desired shape.
Electric Furnace Steel - Steel made in any furnace where heat is generated electrically, almost always by arc. Because of relatively high cost, only tool steels and other high-value steels are made by the electric furnace process.
Face Centered (concerning cubic space lattices) - having equivalent points at the corners of the unit cell and at the centers of its six faces. A face-centered cubic space lattice is characteristic of one of the close-packed arrangements of equal hard spheres.

Fatigue - the phenomenon leading to fracture under repeated or fluctuating stress. Fatigue fractures are progressive beginning as minute cracks and grow under the action of fluctuating stress.
Ferrite - a solid solution of one or more elements in body-centered cubic iron. Unless otherwise designated (for instance, as chromium ferrite), the solute is generally assumed to be carbon. On some equilibrium diagrams there are two ferrite regions separated by an austenite area. The lower area is alpha ferrite; the upper, delta ferrite. If there is no designation, alpha ferrite is assumed.
Ferrous - related to iron (derived from the Latin ferrum). Ferrous alloys are, therefore, iron base alloys.
Finery - a charcoal-fueled hearth furnace used in early processes for converting cast iron to wrought iron by melting and oxidizing it in an air blast, then repeatedly oxidizing the product in the presence of a slag. The carbon oxidizes more rapidly than the iron so that a wrought iron of low carbon content is produced.
Flakes - short discontinuous internal fissures in ferrous metals attributed to stresses produced by localized transformation and decreased solubility of hydrogen during cooling after hot working. In a fractured surface, flakes appear as bright silvery areas; on an etched surface thay appear as short discontinuous cracks. Also called shatter cracks and snowflakes.
Flux - (1) In refining, a material used to remove undesirable substances as a molten mixture. It may also be used as a protective covering for molten metal. (2) In welding, a material used to prevent the formation of, or to dissolve and facilitate the removal of, oxides and other undesirable substances.
Forging - plastically deforming metal, usually hot, into desired shapes with compressive force, with or without dies.
Grain - a solid polyhedral (or many sided crystal) consisting of groups of atoms bound together in a regular geometric pattern. In mill practice grains are usually studied only as they appear in one plane. (1) (Direction of) Refers to grain fiber following the direction of rolling and parallel to edges of strip or sheets. (2) To bend across the grain is to bend at right angles to the direction of rolling. (3) To bend with the grain is to bend parallel to the direction of rolling. In steel, the ductility in the direction of rolling is almost twice that at right angles to the direction of rolling

Hardness - degree to which a metal will resist cutting, abrasion, penetration, bending and stetching. The indicated hardness of metals will differ somewhat with the specific apparatus and technique of measuring. For details concerning the various types of apparatus used in measuring hardness, See Brinell Hardness, Rockwell Hardness, Vickers Hardness, Scleroscope Hardness. Tensile Strength also is an indication of hardness.
Heat Treatment - heating and cooling a solid metal or alloy in such a way that desired structures, conditions or properties are attained. Heating for the sole purpose of hot working is excluded from the meaning of this term.
Hematite - the oxide of iron of highest valency which has a composition close to the stoichiometric composition Fe_2O_3.
High Brass is 65% a copper-zinc alloy containing 35% zinc. It possesses high tensile strength is used for springs, screws, rivets, etc.
Hot Working - deformation under conditions that result in recrystallization.
Hot Working - plastic deformation of metal at a temperature sufficiently high not to create strain hardening. The lower limit of temperature for this process is the recrystallization temperature.
Impurities - are elements or compounds whose presence in a material is undesired.
Inclusion - is a nonmetallic material in a solid metallic matrix.
Inclusions - are particles of impurities (usually oxides, sulfides, silicates, etc.) that are held mechanically or are formed during the solidification or by subsequent reaction within the solid metal.
Killed Steel - the term killed indicates that the steel has been sufficiently deoxidized to quiet the molten metal when poured into the ingot mold. The general practice is to use aluminum ferrosilicon or manganese as deoxidizing agents. Properly killed steel is more uniform as to analysis and is comparatively free from aging. However, for the same carbon and manganese content Killed Steel is harder than Rimmed Steel. In general all steels above 0.25% carbon are killed, also all forging grades, structural steels from 0.15% to 0.25% carbon and some special steels in the low carbon range. Most steels below 0.15% carbon are rimmed steel.

Lattice - space lattice. Lattice lines and lattice planes are lines and planes chosen so as to pass through collinear lattice points, and non-collinear lattice points, respectively.
Leveling - flattening rolled metal sheet or strip.
Light Metal - one of the low-density metals such as aluminum, magnesium, titanium, beryllium, or their alloys and have a low specific gravity, such as beryllium, magnesium and aluminum.
Malleability -the property that determines the ease of deforming a metal when the metal is subjected to rolling or hammering. The more malleable metals can be hammered or rolled into thin sheet more easily than others.
Nickel - (Chemical symbol Ni) Element No. 28 of the periodic system; atomic weight 58.69. Silvery white, slightly magnetic metal, of medium hardness and high degree of ductility and malleability and resistance to chemical and atmospheric corrosion; melting point 2651 (degrees) F.; boiling point about 5250 (degrees) F., specific gravity 8.90. Used for electroplating. Used as an alloying agent, it is of great importance in iron-base alloys in stainless steels and in copper-base alloys such as Cupro-Nickel, as well as in nickel-base alloys such as Monel Metal. Its principal functions as an alloy in steel making: (**1**) Strengthens unquenched or annealed steels. (**2**) Toughens pearlitic-ferritic steels (especially at low temperature). (**3**) Renders high-chromium iron alloys austenitic.
Physical Properties - those properties familiarly discussed in physics, exclusive of those described under mechanical properties; for example, density, electrical conductivity, co-efficient of thermal expansion. This term often has been used to describe mechanical properties, but this usage is not recommended.
Pig Iron - is iron produced by reduction of iron ore in a blast furnace. Pig iron contains approximately 92% iron and about 3.5% carbon. Balance largely silicone and manganese with small percentages of phosphorus, sulphur, and other impurities. (**1**) High-carbon iron made by reduction of iron ore in the blast furnace. (**2**) Cast Iron in the form of pigs.
Quenching - in the heat treating of metals, the step of cooling metals rapidly in order to obtain desired properties; most commonly accomplished by immersing the metal in oil or water. In the case of most copper base alloys, quenching has no effect other than to hasten cooling.

Smelting (*v*) - smelting, is a form of extractive metallurgy used to produce a metal from its basic ore components.
Soldering - joining metals by fusion of alloys that have relatively low melting points - most commonly, lead-base or tin-base alloys, which are the soft solders. Hard solders are alloys that have silver, copper, or nickel bases and use of these alloys with melting points higher than 800 (degrees) F. is generally termed brazing.
Tin - chemical symbol **Sn**. Element No. 50 of the periodic system; atomic weight 118.70. Soft silvery white metal of high malleability and ductility, but low tensile strength; melting point
449 (degrees) F., boiling point 4384 (degrees) F., yielding the longest molten-state range for any common metal; specific gravity 7.28. Principal use as a coating on steel in tin plate; also as a constituent in alloys.
Tungsten - chemical symbol **W**. Element No. 74 of the periodic system; atomic weight 183.92. Gray metal of high tensile strength, ductile and malleable when specially handled. It is immune to atmospheric influences and most acids, but not to strong alkalis. The metal is used as filament and in thin sheet form in incandescent bulbs and radio tubes. (1) Forms hard abrasion -- resistant particles in tool steels. (2) Promotes hardness and strength at elevated temperatures.
Zinc - chemical symbol **Zn**. Element No. 30 of the periodic system; atomic weight 65.38. Blue-white metal; when pure, malleable and ductile even at ordinary temperatures; melting point 787 (degrees) F.; boiling point 1665 (degrees) F., specific gravity 7.14. Can be electrodeposited; it is extensively used as a coating for steel and sheet zinc finds many outlets, such as dry batteries, etc. Zinc-base alloys are of great importance in die casting. Its most important alloy is brass.

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