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ИНОСТРАННЫЙ ЯЗЫК

ХИМИЧЕСКАЯ ТЕХНОЛОГИЯ НЕОРГАНИЧЕСКИХ ВЕЩЕСТВ

Методические указания к практическим занятиям для студентов бакалавриата направления 18.03.01

FOREIGN LANGUAGE

CHEMICAL ENGINEERING OF INORGANIC SUBSTANCES

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ИНОСТРАННЫЙ ЯЗЫК. Химическая технология неорганических веществ: Методические указания к практическим занятиям / Санкт-Петербургский горный университет. Сост.: И.С. *Облова, О.А. Кочергина.* СПб, 2021**.** 31 с.

Методические указания к практическим занятиям студентов бакалавриата направления 18.03.01 «Химическая технология» (Специализация «Химическая технология неорганических веществ») согласованы с программой дисциплины «Иностранный язык» для студентов неязыковых вузов.

Изучение аутентичных научно-технических текстов по химической технологии на английском языке направлено на совершенствование навыков просмотрового и изучающего чтения, а также расширения словарного запаса студентов бакалавриата в рамках профессиональной тематики.

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Предисловие

Целью методических указаний, предназначенных для практической работы студентов специальности 18.03.01 «Химическая технология» специализация «Химическая технология неорганических веществ», изучающих английский язык, является развитие навыков просмотрового и изучающего чтения. Особое внимание уделяется накоплению активного словарного запаса, состоящего из наиболее употребительных для специальности терминов и слов общетехнического значения в рамках совершенствования иноязычной профессиональной коммуникативной компетенции бакалавров.

Предлагаемые методические указания содержат аутентичные тексты на английском языке с разработанным комплексом предтекстовых и послетекстовых упражнений, способствующих активизации познавательной деятельности студентов и повышению их уровня мотивации к изучению иностранного языка. Тематика научно-технических текстов затрагивает основные объекты будущей профессиональной деятельности, а именно: химические вещества и материалы; методы и приборы определения состава и свойства веществ и материалов; оборудование, технологические процессы и промышленные системы получения веществ, материалов, изделий, а также системы управления ими и регулирования; методы и средства оценки состояния окружающей среды и защиты ее от влияния промышленного производства, энергетики и транспорта. Работа с материалом поможет овладеть английской технической терминологией из области химии и химических процессов.

Методические указания способствуют комплексному формированию общекультурных и профессиональных компетенций студентов и согласованы с программой по иностранному языку для неязыковых вузов.

UNIT I. Chemical technology

1. In pairs or small groups, discuss what chemical technology is.

2. Read the text carefully and match the paragraphs with their headings. There is one extra heading that you do not need to use.

A. Chemical technology applications
B. Branches of chemical technology
C. Chemical engineering functions
D. Issues chemical technology deals with
E. Efficiency of chemical engineering operations

1.___________ Chemical technology is the development of processes and the design and operation of plants in which materials undergo changes in their physical or **chemical state**. Applied throughout the process industries, it is founded on the principles of chemistry, physics, and mathematics. The **laws** of physical chemistry and physics govern the practicability and efficiency of chemical engineering operations. Energy changes, deriving from thermodynamic considerations, are particularly important. Mathematics is a basic **tool** in optimization and modeling. Optimization means arranging materials, facilities, and energy to yield as productive and economical an operation as possible. Modeling is the construction of theoretical mathematical prototypes of complex process systems, commonly with the aid of computers.

2.___________ Chemical engineers are employed in the design and development of both processes and plant items. In each case, data and predictions often have to be obtained or confirmed with pilot experiments. Plant operation is increasingly the sphere of the chemical engineer rather than the chemist. Chemical engineering provides an ideal **background** for the economic evaluation of new projects and, in the plant construction sector, for marketing.

3.______________ The fundamental principles of chemical technology underlie the operation of processes extending well beyond the boundaries of the chemical industry, and chemical engineers are employed in a range of operations outside traditional areas. Plastics, polymers, and synthetic fibres involve chemical-reaction engineering problems in their manufacture, with **fluid** flow and heat transfer considerations dominating their fabrication. The dyeing of a fibre is a mass-transfer problem. Pulp and paper manufacture involve considerations of fluid flow and heat transfer. While the **scale** and materials are different, these again are found in modern continuous production of foodstuffs. The pharmaceuticals industry presents chemical engineering problems, the solutions of which have been essential to the **availability** of modern drugs. The nuclear industry makes similar demands on the chemical engineer, particularly for fuel manufacture and reprocessing. Chemical engineers are involved in many sectors of the metal processing industry, which extends from steel manufacture to separation of rare metals.

4.______________Further applications of chemical technology are found in the fuel industries. In the second half of the 20th century, considerable numbers of chemical engineers have been involved in space exploration, from the design of fuel cells to the manufacture of **propellants**. Looking to the future, it is probable that chemical technology will provide the solution to at least two of the world's major problems: **supply** of adequate fresh water in all regions through desalination of seawater and environmental control through prevention of **pollution**.

3. With a partner, decide what the words in bold might mean. Read the article again and check your answers.

4. Do the statements below agree with the information given in the text? Write:

True (T) if the statement is true according to the passage.
False (F) if the statement is false according to the passage.
Not given (NG) if the information is not given in the passage.

1. Chemical technology is founded on the principles of chemistry, physics, and mathematics.
2. Practicability and efficiency of chemical engineering operations do not depend on the laws of physical chemistry and physics.
3. Chemical technology emerged upon the development of unit operations, a fundamental concept of the discipline of chemical engineering.

4. Developments in chemical technology before and after World War II were mainly incited by the petrochemical industry.
5. Chemical technology design concerns the creation of plans, specification, and economic analyses for pilot plants, new plants or plant modifications.
6. Chemical engineers are involved in many aspects of plant design and operation, including safety and hazard assessments, process design and analysis, modeling, control engineering, chemical reaction engineering, nuclear engineering, biological engineering, construction specification, and operating instructions.
7. Chemical technology is a branch of engineering that uses principles of chemistry, physics, mathematics, biology, and economics to efficiently use, produce, design, transport and transform energy and materials.

5. Read the questions given below and use them as a basis for discussion in your group or giving individual comments on the problems outlined below. If necessary, refer to the text again.

1. Do you think chemical technology is necessary for the design and development of both processes and plant items?
2. What would happen if there were no highly-qualified chemical engineers in the metal processing industry?
3. Does chemical technology belong to natural or applied sciences?
4. What is the future of chemical technology?

UNIT II. Sodium

1. What do you know about sodium? Talk in small groups and compare your answers with your group mates' ones.
2. Read the following text, divide it into logical parts and name them.

Sodium (Na) is a chemical element of the alkali metal group of the Periodic table. Sodium is a very soft silvery-white metal. Sodium is the most common alkali metal and the sixth most abundant element on Earth, comprising 2.8 percent of Earth's crust. It occurs abundantly in nature in compounds, especially common salt - sodium chloride ($NaCl$) - which forms the mineral halite and constitutes about 80 percent of the dissolved constituents of seawater. Because sodium is extremely reactive, it never occurs in the free state in Earth's crust. In 1807 Sir Humphry Davy became the first to prepare sodium in its elemental form, applying electrolysis to fused sodium hydroxide (NaOH). Sodium is an important constituent of a number of silicate materials, such as feldspars and micas. There are huge deposits of rock salt in various parts of the world, and sodium nitrate deposits exist in Chile and Peru. The sodium content of the sea is approximately 1.05 percent, corresponding to a concentration of approximately 3 percent of sodium halides. Sodium has been identified in both the atomic and ionic forms in the spectra of stars, including the Sun, and the interstellar medium. Analysis of meteorites indicates that the silicate material present has an average content of approximately 4.6 atoms of sodium for every 100 atoms of silicon. Lighter than water, sodium can be cut with a knife at room temperature but it is brittle at low temperatures. It conducts heat and electricity easily and exhibits the photoelectric effect (emission of electrons when exposed to light) to a marked degree. Sodium is by far the most commercially important alkali metal. Most processes for the production of sodium involve the electrolysis of molten sodium chloride. Inexpensive and available in tank-car quantities, the element is used to produce gasoline additives, polymers such as nylon and synthetic rubber, pharmaceuticals, and a number of metals such as tantalum, titanium, and silicon. It is also widely used as a heat exchanger and in sodium-vapour lamps. The yellow colour of the sodium-vapour lamp and the sodium flame (the basis of an analytical test for sodium) is identified with two prominent lines in the yellow portion of the light spectrum. Two of the earliest uses of metallic sodium were in the manufacture of sodium cyanide and sodium peroxide. Significant quantities were used in the manufacture of tetraethyl lead as a gasoline additive, a market that disappeared with the advent of unleaded gasoline. Substantial amounts of sodium are used in the manufacture of sodium alkyl sulfates as the principal ingredient in synthetic detergents. Sodium also is used as a starting material in the manufacture of sodium hydride (NaH) and sodium borohydride (NaBH4). In addition, sodium is employed in the production of dyes and dye intermediates, in the synthesis of perfumes, and in a wide variety of organic reductions. It is used in the purification of hydrocarbons and in the polymerization of unsaturated hydrocarbons. In many organic applications, sodium is used in the form of dispersions in hydrocarbon liquid media. Molten sodium is an excellent heat-transfer fluid, and, because of this property, it has found use as coolant in liquid-metal fast breeder reactors. Sodium is used extensively in metallurgy as a deoxidant and as a reducing agent for the preparation of calcium, zirconium, titanium, and other transition metals. Commercial production of titanium involves reduction of titanium tetrachloride (TiCl4) with sodium. The products are metallic Ti and NaCl.

3. Answer the following questions.

a) What is sodium?

b) What is the chemical symbol for the element Sodium?

c) Is sodium an element or a compound?

d) What is the electron configuration of sodium?

e) Write a balanced chemical equation to represent the reaction of sodium metal with water.

f) Which group is sodium most likely to react with in the periodic table? Why?

g) What is the most common sodium isotope?

h) The most common spectral light of sodium is _______ and it burns a _______ color.

4. Read the second part of the text about the chemical properties of sodium and put the sentences 1-7 in the gaps A-F. There is one extra sentence which you do not need to use.

Generally, elemental sodium is more reactive than lithium, and it reacts with water to form a strong base, sodium hydroxide (NaOH). Sodium is ordinarily quite reactive with air. **(A)** In ordinary air, sodium metal reacts to form a sodium hydroxide film, which can rapidly absorb carbon dioxide from the air, forming sodium bicarbonate.

Sodium does not react with nitrogen, so sodium is usually kept immersed in a nitrogen atmosphere (or in inert liquids such as kerosene or naphtha). In a comparatively dry atmosphere, sodium burns quietly, giving off a dense white caustic smoke, which can cause choking and coughing. **(B)** Special dry-powder fire extinguishers are required, since sodium reacts with carbon dioxide, a common propellant in regular fire extinguishers. Sodium monoxide (Na_2O) is ordinarily formed upon oxidation of sodium in dry air. The superoxide (NaO_2) can be prepared by heating metallic sodium to 300 °C (570 °F) in an autoclave (a heated pressure vessel) containing oxygen at high pressure. Another route to the superoxide is oxidation of sodium peroxide, Na_2O_2, treated to have a large surface area. Sodium that is heavily contaminated with the monoxide may be readily purified by filtration, since the solubility of the oxide in molten sodium is low. **(C)** A second technique for removing the oxide, called cold trapping, involves running the molten sodium through a cooled packed bed of material, upon which the oxide can precipitate. **(D)** The reaction with water of liquid sodium having a high surface area can be explosive.

Pure sodium begins to absorb hydrogen appreciably at about 100 °C (212 °F); the rate of absorption increases with temperature. Pure sodium hydride can be formed at temperatures above 350 °C (660 °F) by exposing sodium to hydrogen gas at a high flow rate. Sodium is completely miscible with the alkali metals below it in the periodic table (potassium, rubidium, and cesium). **(E)** This fluid is the lowest-melting liquid alloy yet isolated. Sodium also forms alloys with the alkaline-earth metals. **(F)** Sodium forms a number of compounds with barium, and several eutectics exist in the system.

1. Its chemistry is well explored.
2. Filtration and cold trapping also are effective in removal of gross quantities of carbonate, hydroxide, and hydride.
3. The temperature of burning sodium increases rapidly to more than 800 °C (1,500 °F), and under these conditions the fire is extremely difficult to extinguish.
4. This low solubility is utilized to a considerable extent in continuous purification processes of sodium in large liquid-metal reactor systems.
5. Sodium is the minor component with potassium and cesium of the ternary alloy NaKCs, melting at −78 °C (−108 °F).
6. The corrosion of solid sodium by oxygen also is accelerated by the presence of small amounts of impurities in the sodium.
7. Beryllium is soluble in sodium only to the extent of a few atomic percent at approximately 800 °C (1,500 °F).

5. Read the third part of the article about sodium principal compounds and complete the blanks with the words from the box.

useful; applications; obtained; compounds; extinguishers; produces; salt; fungicide; source; reactive; is used; raw material; nature; deposits; product; absorbs; fertilizer

Sodium is highly **(1)** …, forming a wide variety of compounds with nearly all inorganic and organic anions. It normally has an oxidation state of +1, and its single valence electron is lost with great ease, yielding the colourless sodium cation (Na^+). Compounds that contain the sodium anion, Na^-, have also been synthesized. The principal commercial sodium **(2)** … are the chloride, carbonate, and sulfate.

The most important and familiar sodium compound is sodium chloride, or common **(3)** …, NaCl. Most other sodium compounds are prepared either directly or indirectly from sodium chloride, which occurs in seawater, in natural brines, and as rock salt. Large quantities of sodium chloride are employed in the production of other heavy (industrial) chemicals as well as being used directly for ice and snow removal, for water conditioning, and in food.

Other major commercial **(4)** … of sodium chloride include its use in the manufacture of chlorine and sodium hydroxide by electrolytic decomposition and in the production of sodium carbonate (Na_2CO_3) by the Solvay process. The electrolysis of aqueous sodium chloride **(5)** … sodium hypochlorite, NaOCl, a compound of sodium, oxygen, and chlorine used in large quantities in household chlorine bleach. Sodium hypochlorite is also utilized as an industrial bleach for paper pulp and textiles, for chlorination of water, and in certain medicinal preparations as an antiseptic and a **(6)** ….

The carbonates contain the carbonate ion (CO_3^{2-}). Sodium bicarbonate, also called sodium hydrogen carbonate, or bicarbonate of soda, $NaHCO_3$ is a **(7)** … of carbon dioxide and so **(8)** … as an ingredient in baking powders, in effervescent salts and beverages, and as the main constituent of dry-chemical fire **(9)** …. Its slight alkalinity makes it **(10)** … in treating gastric or urinary hyperacidity and acidosis. Sodium carbonate, or soda ash, Na_2CO_3, is widely distributed in **(11)** …, occurring as constituents of mineral waters and as the solid minerals natron, trona, and thermonatrite. Large quantities of this alkaline salt are used in making glass, detergents, and cleansers. The monohydrate form of sodium carbonate, $Na_2CO_3 \cdot H_2O$, is employed extensively in photography as a constituent in developers. Sodium sulfate, Na_2SO_4, is a white crystalline solid or powder employed in the manufacture of kraft paper, paperboard, glass, and detergents and as a **(12)** … for the production of various chemicals. It is **(13)** … either from **(14)** … of the sodium sulfate minerals mirabilite and thenardite or synthetically by the treatment of sodium chloride with sulfuric acid. The crystallized **(15)** … is a hydrate, $Na_2SO_4 \cdot 10H_2O$, commonly known as Glauber's salt. Sodium hydroxide (NaOH) is a corrosive white crystalline solid that readily **(16)** … moisture until it dissolves. Commonly called caustic soda, or lye, sodium hydroxide is the most widely used industrial alkali. Sodium nitrate, or soda nitre, $NaNO_3$, is commonly called Chile saltpetre, after its mineral deposits in northern Chile, the principal source. Sodium nitrate is used as a nitrogenous **(17)** … and as a component of dynamite.

UNIT III. Iron

1. Read the quote by Ratan Tata "None can destroy iron, but its own rust can! Likewise none can destroy a person, but its own mindset can!" What do you understand by this quotation? How far do you agree with the idea? Use specific reasons and examples to support your opinion. Scan the following text to check your ideas.

2. Read the text carefully and match the paragraphs with their headings. There is one extra heading that you do not need to use.

A. Allotropes of iron
B. Occurrence and uses
C. Chemical element
D. Isotopes
E. Discovery of iron
F. Chemical properties

1._________ Iron (Fe), chemical element, metal of Group 8 (VIIIb) of the periodic table, the most-used and cheapest metal. Iron makes up 5 percent of Earth's crust and is second in abundance to aluminum among the metals and fourth in abundance behind oxygen, silicon, and aluminum among the elements.

2._________ Iron, which is the chief constituent of Earth's core, is the most abundant element in Earth as a whole (about 35 percent) and is relatively plentiful in the Sun and other stars. In the crust the free metal is rare, occurring as terrestrial iron (alloyed with 2–3 percent nickel) in basaltic rocks in Greenland and carbonaceous sediments in the United States and as a low-nickel meteoric iron, kamacite. Nickel-iron, a native alloy, occurs in terrestrial deposits and in meteorites as taenite (62–75 percent iron, 37–24 percent nickel). Meteorites are classified as iron, iron-stone, or stony according to the relative proportion of their iron and silicate-mineral content. Iron is also found combined with other elements in hundreds of minerals; of greatest importance as iron ore are hematite (ferric oxide, Fe2O3), magnetite (triiron tetroxide, Fe3O4), limonite (hydrated ferric oxide hydroxide, FeO(OH)·nH2O), and siderite (ferrous carbonate, FeCO3). The average quantity of iron in the human body is about 4.5 grams (about 0.004 percent), of which approximately 65 percent is in the form of hemoglobin, which transports molecular oxygen from the lungs throughout the body. Red meat, egg yolk, carrots, fruit, whole wheat, and green vegetables contribute most of the 10–20 milligrams of iron required each day by the average adult.

3.________ Three true allotropes of iron in its pure form occur. Delta iron, characterized by a body-centred cubic crystal structure, is stable above a temperature of 1,390 °C (2,534 °F). Below this temperature there is a transition to gamma iron, which has a face-centred cubic (or cubic close-packed) structure and is paramagnetic (capable of being only weakly magnetized and only as long as the magnetizing field is present); its ability to form solid solutions with carbon is important in steelmaking. At 910 °C (1,670 °F) there is a transition to paramagnetic alpha iron, which is also body-centred cubic in structure. Below 773 °C (1,423 °F), alpha iron becomes ferromagnetic (i.e., capable of being permanently magnetized), indicating a change in electronic structure but no change in crystal structure. Above 773 °C (its Curie point), it loses its ferromagnetism altogether. Alpha iron is a soft, ductile, lustrous, gray-white metal of high tensile strength.

4. ________ Pure iron is quite reactive. In a very finely divided state metallic iron is pyrophoric. It combines vigorously with chlorine on mild heating and also with a variety of other nonmetals, including all of the halogens, sulfur, phosphorus, boron, carbon, and silicon. Metallic iron dissolves readily in dilute mineral acids. With nonoxidizing acids and in the absence of air, iron in the +2 oxidation state is obtained. With air present or when warm dilute nitric acid is used, some of the iron goes into solution as the Fe3+ ion.

5._________ Natural iron is a mixture of four stable isotopes: iron-56 (91.66 percent), iron-54 (5.82 percent), iron-57 (2.19 percent), and iron-58 (0.33 percent).

3. Complete the table with other forms of the words. Mark the stressed syllable in each word.

NOUN	VERB	ADJECTIVE
variety		
	indicate	
	manufacture	
requirement		
		attractive
		reactive
magnet		
	solve	
		solid

4. **Read the second part of the article about iron compounds, underline the key sentences and translate them into Russian.**

The most important oxidation states of iron are +2 and +3, though a number of +4 and +6 states are known. For the element iron the trends in the relative stabilities of oxidation states among elements of the first transition series are continued, except that there is no compound or chemically important circumstance in which the oxidation state of iron is equal to the total number of its valence-shell electrons, eight; the highest known oxidation state is +6, which is rare and unimportant. Even the +3 oxidation state, which is important at the position of chromium in the periodic table, loses ground to the +2 state at the position of iron. Compounds of iron in the +2 state are designated ferrous and contain the pale green Fe^{2+} ion or complex ions. Compounds of iron in the +3 state are called ferric and contain the Fe^{3+} ion (which is yellow to orange to brown, depending on the extent of hydrolysis) or complex ions. Three oxygen compounds of iron are known: ferrous oxide, FeO; ferric oxide, Fe_2O_3; and ferrosoferric oxide, or ferroferric oxide, Fe_3O_4, which contains iron in both +2 and +3 oxidation states. Ferrous oxide is a greenish to black powder used primarily as a pigment for glasses. It occurs in nature as the mineral wuestite and it can be prepared by heating a ferrous compound in the absence of air or by passing hydrogen over ferric oxide. Ferric oxide is a reddish-brown to black powder that occurs naturally as the mineral hematite. It can be produced synthetically by igniting virtually any ferrous compound in air. Ferric oxide is the basis of a series of pigments ranging from yellow to a red known as Venetian red. The finely powdered red form, often called jewelers' rouge, is used for polishing precious metals and diamonds, as well as in cosmetics. Ferric oxide forms a number of hydrates with variable structures and compositions. A common form is iron rust, produced by the combined action of moisture, carbon dioxide, and oxygen in the air on metallic iron. Ferrosoferric oxide occurs as the mineral magnetite in the form of magnetic, black or red-black crystals. It is prepared by passing steam over red-hot iron. The oxide is widely employed in ferrites, substances with high magnetic permeability and high electrical resistivity used in certain computer memories and coatings for magnetic tape. It is also used as a pigment and a polishing agent.

The action of sulfuric acid on iron results in the formation of two sulfur compounds: ferrous sulfate, $FeSO_4$, which is commonly available as the heptahydrate $FeSO_4 7H_2O$; and ferric sulfate, $Fe_2(SO_4)_3$. Ferrous sulfate heptahydrate, known in commerce as green vitriol, or copperas, is obtained as a by-product of industrial processes using iron ores that have been treated with sulfuric acid. It serves as a starting material for the manufacture of various other ferrous compounds and as a reducing agent. It is also employed in making inks, fertilizers, and pesticides and for iron electroplating. A number of iron compounds have been found medically useful. For example, ferrous gluconate, $Fe(C_6H_{11}O_7)_2 \cdot 2H_2O$, and ferric pyrophosphate, $Fe_4(P_2O_7) \cdot xH_2O$, are among the compounds frequently used to treat anemia. Various ferric salts, which act as coagulants, are applied to wounds to promote healing.

5. Read the article again. Do the statements agree with the information given in the text? Write:

True (**T**) if the statement is true according to the passage.
False **(F)** if the statement is false according to the passage.
Not given (**NG**) if the information is not given in the passage.

1. From being a crucial building block of steel to nourishing plants and helping carry oxygen in your blood — iron is always busy helping sustain life on the Earth.
2. The phase of iron at room temperature is solid.
3. Iron is a brittle, hard substance, classified as a metal in Group 8 on the Periodic Table of the Elements.
4. Iron is also the first most common element in Earth's crust by weight and much of Earth's core is thought to be composed of iron.
5. The number of isotopes (atoms of the same element with a different number of neutrons) - 33. Stable isotopes - 4.
6. Archeologists estimate that people have been using iron for more than 5,000 years.
7. Iron has four different allotropic forms, which means that it has four different structural forms in which atoms bond in different patterns.

UNIT IV. The Modern Steel Production Process

1. What types of steel do you know? What main challenges is steel industry facing now? Compare your opinion to your partner's one. Scan the article and see if your guesses were correct.

2. Read the article below and answer the following questions.

1. What proportion of world steel output is stainless steel?
2. What country is the world's biggest exporter of scrap?
3. What is the difference between hot rolled steel and cold rolled steel?

4. What amount of steel does BOS (Basic Oxygen Steelmaking) Vessel take?
5. What is a blast furnace**?**

Steel is the world's most popular construction material because of its unique combination of durability, workability, and cost. It's an iron alloy that contains 0.2-2% carbon by weight. According to the World Steel Association, some of the largest steel-producing countries are China, India, Japan, and the USA. China accounts for roughly 50% of this production.

Methods for manufacturing steel have evolved significantly since industrial production began in the late 19th century. Modern methods, however, are still based on the same premise as the original Bessemer Process, which uses oxygen to lower the carbon content in iron. Today, steel production makes use of recycled materials as well as traditional raw materials, such as iron ore, coal, and limestone. Two processes, basic oxygen steelmaking (BOS) and electric arc furnaces (EAF), account for virtually all steel production. Ironmaking, the first step in making steel, involves the raw inputs of iron ore, coke, and lime being melted in a blast furnace. The resulting molten iron—also referred to as hot metal—still contains 4-4.5% carbon and other impurities that make it brittle.

Primary steelmaking has two methods: BOS (Basic Oxygen Furnace) and the more modern EAF (Electric Arc Furnace) methods. The BOS method adds recycled scrap steel to the molten iron in a converter. At high temperatures, oxygen is blown through the metal, which reduces the carbon content to between 0-1.5%. The EAF method, however, feeds recycled steel scrap through high-power electric arcs (with temperatures of up to 1,650 degrees Celsius) to melt the metal and convert it into high-quality steel.

Secondary steelmaking involves treating the molten steel produced from both BOS and EAF routes to adjust the steel composition. This is done by adding or removing certain elements and/or manipulating the temperature and production environment. Depending on the types of steel required, the following secondary steelmaking processes can be used:

- stirring;

- ladle furnace;
- ladle injection;
- degassing;
- CAS-OB (composition adjustment by sealed argon bubbling with oxygen blowing)

Continuous casting sees the molten steel cast into a cooled mold, causing a thin steel shell to solidify. The shell strand is withdrawn using guided rolls, then it's fully cooled and solidified. Next, the strand is cut depending on application—slabs for flat products (plate and strip), blooms for sections (beams), billets for long products (wires), or thin strips. In primary forming, the steel that is cast is then formed into various shapes, often by hot rolling, a process that eliminates cast defects and achieves the required shape and surface quality. Hot rolled products are divided into flat products, long products, seamless tubes, and specialty products.

Finally, it's time for manufacturing, fabrication, and finishing. Secondary forming techniques give the steel its final shape and properties. These techniques include:

- shaping (cold rolling), which is done below the metal's recrystallization point, meaning mechanical stress—not heat—affects change;
- machining (drilling);
- joining (welding);
- coating (galvanizing);
- heat treatment (tempering);
- surface treatment (carburizing).

3. a. Here are some of the words from the passage. Check you know what they mean. Try to remember the sentence in the passage in which you saw them.

steelmaking; cause; evaluation; processing; include; final; manufacturing; primary; thin strips; adjust; seamless tubes

b. Look back at the passage and check.

c. Decide what part of speech they are – nouns, verbs or adjectives. Then, underline the verbs. Which nouns go with them?

4. Match the following terms with their definitions.

1. Welding	A. To heat and then cool a metal in order to make it hard.
2. Drilling	B. A type of motion that combines rotation and translation of that object with respect to a surface, such that, if ideal conditions exist, the two are in contact with each other without sliding.
3. Tempering	C. A fabrication process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool, causing fusion.
4. Rolling	D. A manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify.
5. Casting	E. A cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials.

5. Finish the following sentences.

1. Steel is …
2. Methods for manufacturing steel have evolved …
3. Primary steelmaking has two methods …
4. Depending on the types of steel required, the following secondary steelmaking processes …
5. Hot rolled products are divided into …
6. Finally, it's time for …
7. Secondary forming techniques give the steel **…**

UNIT V. Industrial steelmaking

1. In two minutes write down as many words connected with the operations of steelmaking as you can. Talk in small groups and compare your results with your group mates' ones.

2. Read the text and find out which of the following sentences are true.

a) It was discovered that the addition of iron oxide to the charge of the pudding furnace caused a violent reaction by Hall.

b) Violent reaction in which the pig iron was decarburised became known as 'wet pudding'.

c) In the early 19th century, Hall improved the blast furnace by the change to hot blast.

d) James Beaumont Neilson developed the efficiency of the blast furnace by the change to hot blast and reduced production cost.

e) Henry Bessemer introduced first the Bessemer converter at his steelworks in Sheffield, England.

f) In the Bessemer process, molten pig iron from the blast furnace was charged into a large crucible, and then air was blown through the molten iron from below, igniting the dissolved carbon from the coke

g) After the carbon content in the melt had dropped to the desired level, the air draft was cut off: a typical Bessemer converter could convert a 25-ton batch of pig iron to steel in half an hour

h) As the carbon burned off, the melting point of the mixture decreased, but the heat from the burning carbon provided the extra energy needed to keep the mixture molten.

i) The basic oxygen process introduced at the Voest-Alpine works in 1952 is a modification of the basic Bessemer process.

Apart from some production of puddled steel, English steel continued to be made by the cementation process, sometimes followed by remelting to produce crucible steel. These were batch-based processes whose raw material was bar iron, particularly Swedish oregrounds iron. The problem of mass-producing cheap steel was solved in 1855 by Henry Bessemer, with the introduction of the Bessemer converter at his steelworks in Sheffield, England. (An early converter can still be seen at the city's Kelham Island Museum). In the Bessemer process, molten pig iron from the blast furnace was charged into a large crucible, and then air was blown through the molten iron from below, igniting the dissolved carbon from the coke. As the carbon burned off, the melting point of the mixture increased, but the heat from the burning carbon provided the extra energy needed to keep the mixture molten. After the carbon content in the melt had dropped to the desired level, the air draft was cut off: a typical Bessemer converter could convert a 25-ton batch of pig iron to steel in half an hour.

Finally, the basic oxygen process was introduced at the Voest-Alpine works in 1952; a modification of the basic Bessemer process, it lances oxygen from above the steel (instead of bubbling air from below), reducing the amount of nitrogen uptake into the steel. The basic oxygen process is used in all modern steelworks; the last Bessemer converter in the U.S. was retired in 1968. Furthermore, the last three decades have seen a massive increase in the mini-mill business, where scrap steel only is melted with an electric arc furnace. These mills only produced bar products at first, but have since expanded into flat and heavy products, once the exclusive domain of the integrated steelworks.

Until these 19th century developments, steel was an expensive commodity and only used for a limited number of purposes where a particularly hard or flexible metal was needed, as in the cutting edges of tools and springs. The widespread availability of inexpensive steel powered the second industrial revolution and modern society as we know it. Mild steel ultimately replaced wrought iron for almost all purposes, and wrought iron is not now (or is hardly now) made. With minor exceptions, alloy steels only began to be made in the late 19th century. Stainless steel was only developed on the eve of the First World War and only began to come into widespread use in the 1920s. These alloy steels are all dependent on the wide availability of inexpensive iron and steel and the ability to alloy it at will.

3. Match the following words and word combinations on the left with their English equivalents on the right.

обезуглероживать	production costs
тигельная сталь	waste gas
стоимость изготовления	dissolved carbon

отработанные/отходящие газы	raw material
горячее дутьё	extra energy
составлять (способствовать)	batch
растворенный углерод	basic oxygen process
избыточная энергия	electric arc
сырьё	mills
загрузка сырья	to be decarburized
кислородно-конвертерный процесс	wrought iron
загружать печь	scrap steel
электрическая дуга	Bessemer converter
стальной лом (скрап)	to be charged into
кованое железо	constitute
конвертер Бессемера	hot blast
фабрики	crucible steel

4. Answer the following questions.

a) Who discovered that the addition of iron oxide to the charge of the puddling furnace caused a violent reaction, in which the pig iron was decarburised? When?
b) How and when was the problem of mass-producing cheap steel solved? Who was the inventor?
c) What is the 'Bessemer process', and how did it impact the U.S. during industrialisation?
d) Where is the basic oxygen process used?
5. Read the text again and describe the main operations of steelmaking.

UNIT VI. The Bessemer process

1. Read the title of the article. What engineers would be interested in this article? Complete the following table.

Things I know about the topic	Things I don't know about the topic	Things I'm not sure about

2. Read the article and choose the most suitable heading from the list A-E for each part (1-4) of the text. There is one extra heading which you do not need to use.
A. Managing the process
B. Bessemer Converter
C. Importance of the process
D. Oxidation
E. Molten iron

The Bessemer process

1.

The Bessemer process was the first inexpensive industrial process for the mass-production of steel from molten pig iron. The process is named after its inventor, Henry Bessemer, who took out a patent on the process in 1855. The Process happened inside the Bessemer Converter, the container in which the steel was made. The process was independently discovered in 1851 by William Kelly. The process had also been used outside of Europe for hundreds of years, but not on an industrial scale.

The key principle is removal of impurities from the iron by oxidation through air being blown through the molten iron. The oxidation also raises the temperature of the iron mass and keeps it molten. The Bessemer process revolutionized steel manufacture by decreasing its cost, and greatly increasing the scale and speed, while also decreasing the labour requirements. Prior to its introduction, steel was far too expensive to make bridges or the framework for buildings and wrought iron had been used throughout the Industrial Revolution. After its introduction, steel and wrought iron became similarly priced, and most manufacturers turned to steel.

2.

The process is carried on in a large pear-shaped steel container lined with clay or dolomite called the Bessemer converter. The capacity of a converter was from 8 to 30 tons of molten iron with a usual charge being around 15 tons. At the top of the converter is an opening, usually tilted to the side relative to the body of the vessel, through which the iron is introduced and the finished product removed. The bottom is perforated with a number of channels called tuyères through which air is forced into the converter. The converter is pivoted on trunnions so that it can be rotated to receive the charge, turned upright during conversion, and then rotated again for pouring out the molten steel at the end.

3.

The oxidation process removes impurities such as silicon, manganese, and carbon as oxides. These oxides either escape as gas or form a solid slag. The refractory lining of the converter also plays a role in the conversion - the clay lining is used in the acid Bessemer, in which there is low phosphorus in the raw material. Dolomite is used when the phosphorus content is high in the basic Bessemer (limestone or magnesite linings are also sometimes used instead of dolomite) - this is also known as a Gilchrist-Thomas converter, named after its inventor, Sidney Gilchrist Thomas. In order to give steel the desired properties, other substances could be added to the molten steel when conversion was complete, such as spiegeleisen (an iron-carbon-manganese alloy).

4.

When the required steel had been formed, it was poured out into ladles and then transferred into moulds and the lighter slag is left behind. The conversion process called the "blow" was completed in around twenty minutes. During this period the progress of the oxidation of the impurities was judged by the appearance of the flame issuing from the mouth of the converter: the modern use of photoelectric methods of recording the characteristics of the flame has greatly aided the blower in controlling the final quality of the product. After the blow, the liquid metal was recarburized to the desired point and other alloying materials are added, depending on the desired product.

3. a). Give English equivalents to the following words and expressions.

Грушевидный, огнеупорный материал, горловина конвертора, «продутый металл», свойства конечного продукта, расплавленный чугун, основной принцип процесса, футеровка конвертора, потребность в рабочей силе, изложница, жидкое состояние металла, науглероживать, каркас, цапфа, вместимость конвертора.

b). Look at the text and find words which mean the same as:

Holes, combustion, to furnish, to carry on the process, to issue from, to finish the operation, desired steel, to be named after.

4. Draw the Bessemer converter and use these words and expressions to label it.

Mouth, opening, body of the vessel, tuyeres, vessel lining, trunnions.

5. **Match the terms with their definitions**.

a) A furnace used to produce steel by flowing air through molten pig iron.	tuyere
b) A layer of a heat resisting material on the inside of a furnace	refractories
c) Any of a class of chemical elements, such as iron, gold, aluminium, etc., generally characterized by ductility, malleability, luster, and conductivity of heat and electricity.	photoelectric
d) The carefully shaped hole into which	wrought iron

molten metal is poured.	
e) Using electricity produced by photocells.	mould
f) Crude iron as produced from the blast furnace and containing carbon, silicon, and other impurities.	lining
g) Firebricks or other heat-resisting materials used for lining furnaces and retaining the heat without allowing the outer shell of the furnace to be damaged.	metal
h) The pipe or nozzle through which air is forced into a furnace.	converter
i) More or less pure iron, hardened slightly by heating and hammering.	pig iron

6. Translate the text.

Конвертер представляет собой сосуд грушевидной формы, изготовленный из стального листа и футерованный внутри огнеупорным материалом. К цилиндрической части конвертера крепятся цапфы, на которых конвертер вращается. Вместимость современных конвертеров достигает 300-400 т.

UNIT VII. Technology of the basic oxygen steelmaking

1. Using a dictionary, practice pronouncing the following words. Translate these words and make up as many word combinations or sentences using these words as you can:

oxygen; furnace; scarp; refractory-lined; lance; nozzle; charge; trunnion ring; lining; converter; pour; incline; slag.

2. What do you already know about steelmaking? Read the article and answer the following questions.

a) How much steel is produced by basic oxygen steelmaking?

b) What vessel is used in this process?

c) How many stages does basic oxygen steelmaking consist of?

More than half the world's steel is produced in the basic oxygen process, which uses pure oxygen to convert a charge of liquid blast-furnace iron and scrap into steel. The basic oxygen furnace is a refractory-lined, tiltable converter into which a vertically movable, water-cooled lance is inserted to blow oxygen through nozzles at supersonic velocity onto the charge.

Making a heat begins with an inspection of the refractory lining, with the converter in a turned-down position. With the converter tilted at about 45^0C, scrap is then charged into the furnace by heavy cranes or special charging machines that drop one or two large boxes full of scrap through the converter mouth. Hot metal is poured into the converter by a special iron-charging ladle; this ladle receives the iron at a transfer station from transport ladles, which bring the iron from the blast furnace. Then slag-forming materials are charged into the converter.

Owing to predictable losses during the oxygen blow, there is always more iron and scrap charged than steel produced. Chemical composition, temperatures, and charging weights of the iron are often fed automatically into a control computer.

For blowing, the converter is placed in an upright position, oxygen is turned on, and the lance is lowered. Oxygen flow rates, lance height, and lime additions are often controlled automatically.

For tapping, the converter is inclined, and steel is poured through the taphole into a ladle sitting on a transfer car beneath the converter.

When slag appears, the converter is tilted all the way back, and the slag is poured over the converter mouth into a slag pot.

Basic oxygen furnaces have a tap-to-tap time of 30 to 45 minutes and can blow more than 30 heats per day.

3. Find English equivalents of the following Russian words / word combinations / phrases in the text.

Кожух; лётка; фурма; загрузочное оборудование; конвейерная лента; данные о химическом составе; автоматически заносить в компьютер управления; ковш, расположенный на трансферкаре; доменный чугун; весь цикл составляет 30-45 минут.

4. Write out the words with the same root from the text, define their part of speech and translate them into Russian.

Appearance; to blow; to control; to compose; checking; a brick; to convert; to feed; heating; to charge; to tilt; automation; to tap; to lose; heavily; to test; to predict.

5. Describe the stages of the basic oxygen process using these words and expressions.

1 Scrap charging;
2 Liquid iron pouring;
3 Slag-forming injecting;
4 Blowing;
5. Steel taping;
6. Slag off.

6. Translate the following text into English.

Кислородно-конверторный процесс осуществляется следующим образом. Вначале в конвертер загружают стальной лом, и затем заливают жидкий чугун и шлакообразующие материалы. После этого опускают кислородную фурму и начинают продувку металла. После окончания плавки выпускают сталь и шлаг. Общая продолжительность цикла составляет 50-60 минут.

Compare the text above with the article. Find similarities and differences between them.

Self-essesment

1. Make up a description of any inorganic substances you like.
2. Describe the process of steel production.

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Методические указания к практическим занятиям для студентов бакалавриата направления 18.03.01

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