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ТЕХНИЧЕСКИЙ ИНОСТРАННЫЙ ЯЗЫК

ХИМИЧЕСКАЯ ТЕХНОЛОГИЯ ПРИРОДНЫХ ЭНЕРГОНОСИТЕЛЕЙ И УГЛЕРОДНЫХ МАТЕРИАЛОВ

Методические указания к практическим занятиям
со студентами магистратуры направления подготовки 18.04.01

CHEMICAL ENGINEERING OF NATURAL ENERGY CARRIERS AND CARBON MATERIALS

САНКТ-ПЕТЕРБУРГ

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ТЕХНИЧЕСКИЙ ИНОСТРАННЫЙ ЯЗЫК. Химическая технология природных энергоносителей и углеродных материалов (English for Specific Purposes. Chemical Engineering of Natural Energy Carriers and Carbon Materials): Методические указания к практическим занятиям / Санкт-Петербургский горный университет. Сост.: *И.С. Рогова*. СПб, 2022. 66с.

Методические указания предназначены для практических занятий со студентами магистратуры направления 18.04.01 Химическая технология (Химическая технология природных энергоносителей и углеродных материалов) и согласованы с программой по техническому иностранному языку для студентов неязыковых вузов.

Предлагаемый материал направлен на совершенствование навыков чтения, понимания и перевода технических текстов, построения высказываний на основе полученной информации, а также на развитие навыков самостоятельной работы с аутентичным материалом в рамках профессиональной направленности. В методические указания включены оригинальные тексты, сопровождающиеся комплексом упражнений с целью овладения иноязычной профессиональной компетенцией.

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ПРЕДИСЛОВИЕ

Данные методические указания предназначены для практических занятий со студентами магистратуры направления 18.04.01 «Химическая технология (Химическая технология природных энергоносителей и углеродных материалов)», а также могут быть полезны для студентов вузов технического профиля близких специальностей. Методические указания составлены в соответствии с учебной программой по дисциплине « Технический иностранный язык» для формирования иноязычной профессиональной компетенции будущих специалистов.

Предложенные аутентичные материалы и разработанный к ним комплекс упражнений направлены на совершенствование навыков устной и письменной иноязычной речи в контексте профессионально-ориентированного общения. Тематика текстов охватывает различные виды горючих полезных ископаемых, а также историю, современное состояние и будущее технологий переработки природных энергоносителей.

Большая часть заданий нацелена на отработку навыков перевода, а также навыков ознакомительного и поискового чтения.

Особое внимание уделяется расширению словарного запаса, который включает наиболее употребительные для специальности термины и слова общетехнического значения.

UNIT 1 NONRENEWABLE ENERGY SOURCES

Text 1
Energy Sources and Energy Carriers

1.	**fossil fuels**	горючие ископаемые
2.	**biogenic**	биогенный, органического происхождения
3.	**renewable**	возобновляемый
4.	**non-renewable**	невозобновляемый
5.	**combustion**	горение
6.	**primary energy source**	первичный источник энергии
7.	**energy carrier**	энергоноситель
8.	**valuable**	ценный
9.	**steam engine**	паровой двигатель
10.	**combustion engine**	двигатель внутреннего сгорания
11.	**burgeoning** ['bɜːdʒənɪŋ]	активно развивающийся
12.	**feedstock**	сырьё
13.	**mainstay**	главная опора
14.	**energy supply**	энергоснабжение
15.	**recoverable**	извлекаемый
16.	**decimate** ['desɪmeɪt]	опустошать, истреблять
17.	**energy efficiency**	энергетическая эффективность
18.	**energy demand**	энергопотребление
19.	**finiteness** ['faɪnaɪtnəs]	ограниченность (напр., ресурсов)
20.	**environmental repercussion** ['riːpə'kʌʃ(ə)n]	экологический бумеранг
21.	**root cause**	основная причина
22.	**carbon dioxide**	углекислый газ

I. Translate the following international words without a dictionary:

Energy, biomass, geothermal, technology, physical, industrial revolution, atmosphere, permanent.

II. Analyze the suffixes of the following words and match the latter to the corresponding part of speech:

NOUN	ADJECTIVE

Biogenic, gaseous, conversion, valuable, petrochemical, invention, electricity, requirement, storage, important, safety.

III. Analyze the prefixes of the following words and translate them:

Hydropower, hydroelectric, non-renewable, nonessential, indirectly.

IV. Pay attention to the translation of the following words and phrases:

Over the course of millions of years, are distinguished into, by contrast, due to, at least, dependence on, with regard to, are associated with.

V. Identify the type of the sentences: Simple/Composite (Compound or Complex).

1. Fossil fuels include all sources of energy derived from finite resources.
2. Mineral fossil fuels are substances from which nuclear energy can be produced.
3. This process began with the coal-powered steam engine.
4. Fossil fuels developed from dead biomass by being exposed to high pressure and heat in the absence of oxygen.
5. Since the energy is released directly during combustion, biogenic fossil fuels are counted among the primary energy sources.

VI. Look at the title of the text and the vocabulary to predict what the text is about.

VII. Skim through the text (= read quickly to get the gist) to check your ideas.

VIII. Scan through the text (= read quickly to pick out particular information) and find out what the following abbreviations stand for:

EC, PES, MJ, HSSE.

IX. Read and translate the following text.

Fossil fuels include all sources of energy derived from finite resources. Fossil fuels developed from dead (plant and animal) biomass that was converted into what they are today by being exposed to high pressure and heat in the absence of oxygen over the course of millions of years. The main fossil fuels are coal, natural gas and crude oil.

Fossil energy sources are distinguished into **biogenic** and mineral fossil energy sources. Biogenic fossil fuels are mainly coal (e.g. lignite, bituminous coal) and liquid or gaseous hydrocarbons (e.g. crude oil, natural gas). Unlike the **renewable** energy sources – bio-energy, wind energy, hydropower, solar energy and geothermal energy – biogenic fossil fuels are **non-renewable**. Mineral fossil fuels are substances from which nuclear energy can be produced.

Since the energy is released directly during **combustion**, biogenic fossil fuels are counted among the **primary energy sources**. They can be used to generate energy either directly or through one or more conversion steps indirectly by producing secondary **energy carriers**. An example of secondary energy carriers is refining crude oil into various petroleum products such as gasoline and diesel, which then go to fuel vehicles at filling stations.

In the field of energetics, an energy carrier is produced by human technology from a primary energy source. The distinction between "Energy Carriers" (EC) and "Primary Energy Sources" (PES) is extremely important. An energy carrier can be more **valuable** (have a higher quality) than a primary energy source. For example 1 megajoule (MJ) of electricity produced by a hydroelectric plant is equivalent to 3 MJ of oil.

Historically speaking, in the 18^{th} and 19^{th} centuries the physical exploitation and use of fossil fuels formed the basis for the industrial revolution. This process began with the coal-powered **steam engine**. The invention of the **combustion engine** and the **burgeoning** petrochemical industry meant that coal has been increasingly replaced by oil. Crude oil is still the most important fossil fuel and also the **feedstock** for most chemical products. At present, biogenic and mineral fossil primary energy are the **mainstays** of our **energy supply** system.

The existing reserves of fossil fuels on earth that are proven to be safely and economically **recoverable** with current technology are called "energy reserves." By contrast, the term "energy resources" is used to describe proven and probable stores of energy sources that cannot yet be exploited for technical and/or economic reasons.

Due to their widespread use and the world's growing energy requirements, fossil energy reserves are being steadily **decimated**. Use of renewable energy is being increased in an attempt to at least partially replace fossil fuels and reduce our dependence on fossil energy. Cutting back on nonessential use and increasing **energy efficiency** also help to reduce **energy demand**.

The increased use of renewable energy is being accelerated not only with the **finiteness** of fossil fuels in mind, but also with regard to the **environmental repercussions** associated with their use. The combustion of fossil energy releases **carbon dioxide** (CO_2) into the atmosphere. The permanent increase in CO_2 concentrations is seen as a **root cause** of accelerating climate change. The extraction, transport, storage and handling of fossil fuels are also associated with risks, which is why HSSE (health, safety, security & environment) plays an important role in energy companies.

X. Answer the following questions:

1. What do fossil fuels include?
2. What are renewable and non-renewable energy sources?
3. What are examples of secondary energy carriers?
4. Can an energy carrier be more valuable than a primary energy source? Explain.
5. When was the basis for the industrial revolution formed?
6. In what ways do "energy reserves" differ from "energy resources"?
7. Why is the increased use of renewable energy being accelerated?

XI. Give a short summary of the text according to the following structure and basic rules:

– По объему пересказ примерно на одну треть меньше оригинального текста. – Сложные грамматические конструкции письменной речи и перегруженные в смысловом отношении предложения заменяются более простыми, характерными для устной речи.

– В пересказе используются слова-связки, логически организующие изложение. **План пересказа** 1. Название текста. 2. Основная мысль текста. 3. Основная мысль каждого абзаца с примерами из текста. 4. Вывод и отношение к передаваемому содержанию.
1. The title of the text is … . **2. The text** deals with/tells about/is about/is concerned with… . **3. The text can be divided** into 2/3/4 logical parts/paragraphs**.** **4. At the beginning of the text** the author describes/explains/ characterizes/enumerates/stresses/underlines… . **The text begins with** the description of/the analysis of/the review of/ … . **5. Then** (After that, Next) the author passes on to/goes on to say about/gives a detailed analysis (description) of … . **6. In addition** (Moreover, Furthermore) … . **7. In conclusion** the author underlines/ points out/criticizes that … **To sum up,** … . **8. In my opinion/ From my point of view,** the text is interesting/ useful/ valuable/contains new information … .

Text 2
Fuels and the Global Carbon Cycle

1.	**yield**	выход (продукции); выработка (напр., электроэнергии)
2.	**mitigate**	смягчать, уменьшать (нежелательные последствия)
3.	**gasoline performance**	характеристика бензина
4.	**convenient**	удобный; подходящий
5.	**conversion**	преобразование; переработка
6.	**chemical composition**	химический состав
7.	**commonality**	общая черта
8.	**representative sample**	типичный образец, показательный образец
9.	**carbon**	углерод
10.	**global carbon cycle**	глобальный углеродный цикл

11. **flux**	течение; постоянное движение
12. **sink**	поглотитель
13. **sequester**	изолировать
14. **consequence** ['kɔnsɪkwəns]	последствие
15. **rate**	скорость, интенсивность (изменения, процесса);
16. **decay**	разложение
17. **exceed**	превышать
18. **solid evidence**	надежные данные, убедительные доказательства
19. **outrun**	опережать, обгонять
20. **profound changes**	глубокие изменения, кардинальные перемены
21. **shrinkage of glaciers**	сокращение ледников
22. **desertification**	опустынивание
23. **frequency**	частота; частотность
24. **consistent with**	согласующийся с
25. **water vapor**	водяной пар
26. **nitrous oxide**	оксид азота
27. **chlorofluorocarbons** [ˌklɔːrəˌflʊərə'kɑːbən]	хлорфторуглероды
28. **buttress**	подкреплять; служить опорой; поддержать
29. **circumstantial evidence** ['sɜːkəm'stænʃ(ə)l'evɪd(ə)ns]	косвенные доказательства
30. **sole cause**	единственная причина
31. **renewable fuel**	возобновляемое топливо
32. **contribution**	доля; вклад
33. **resurgence** [rɪ'sɜːʤ(ə)ns]	возрождение
34. **transition state**	переходное состояние

I. Translate the following international words without a dictionary:

Practical, situation, potential, problem, organic, material, form, molecular, structure, element.

II. Analyze the suffixes of the following words and match the latter to the corresponding part of speech:

NOUN	ADVERB	ADJECTIVE

Performance, advantageous, environmental, useful, particularly, combustion, directly, removal, conveniently, utilization, evidence, atmospheric.

III. Translate the following linking expressions:

So, first, examples include, also, it is likely that, despite, thus, nevertheless, perhaps, furthermore.

IV. Pay attention to the translation of <u>since</u> (preposition or conjunction):

1. **Since** 1965 petroleum has dominated the world energy scene.
2. **Since** the energy is released directly during combustion, biogenic fossil fuels are counted among the primary energy sources.

V. Identify the Voice (Active/Passive) of <u>the predicates</u> and translate them.

1. This ***<u>might be done</u>*** to improve the yield of the fuel from its source.
2. Examples ***<u>include</u>*** processes to enhance the yield of gasoline from petroleum.
3. We ***<u>have been burning</u>*** them on a large, and ever-increasing, scale only for about 250 years.
4. Fuels ***<u>can be used</u>*** in at least three different ways.
5. The transformations of carbon in nature ***<u>are</u>*** conveniently ***<u>summarized</u>*** in a diagram of the global carbon cycle.
6. Carbon fluxes from the sources ***<u>are</u>*** indeed ***<u>outrunning</u>*** fluxes back into the sinks.

VI. Look at the title of the text and the vocabulary to predict what the text is about.

VII. Skim through the text (= read quickly to get the gist) to check your ideas.

VIII. Scan through the text and find: at least three different ways we can use fuels

IX. Read and translate the following text.

Fuels are substances that are burned to produce energy. In many practical situations, it can be advantageous first to carry out one or more processing steps on a fuel before it is burned. This might be done to improve the **yield** of the fuel from its source, to improve the performance of the fuel during combustion, or to **mitigate** potential environmental problems resulting from using the fuel. Examples include processes to enhance the yield of gasoline from petroleum, to improve **gasoline performance** in engines, and to convert solid coal into cleaner gaseous or liquid fuels. Some fuels, particularly natural gas and petroleum, also serve as important feedstocks for the organic chemical industry, for producing a host of useful materials.

So, fuels can be used in at least three different ways:

- burned directly to release thermal energy;
- chemically transformed to cleaner or more **convenient** fuel forms;
- or converted to non-fuel chemicals or materials.

The ways in which we use fuels, and their behavior during **conversion** or utilization processes, necessarily depend on their **chemical composition** and molecular structure.

Despite apparent differences, there are two very important points of **commonality**. First, all of these fuels occur directly in nature or are made from materials that occur in nature. The second point becomes apparent when we consider the chemical compositions of **representative samples**, see Table 1. In every case the predominant element, on a mass basis, is **carbon**.

	Carbon	*Hydrogen*	*Oxygen*	*Nitrogen*	*Sulfur*
Biodiesel	76	13	11	0	0
Coal, bituminous	83	5	8	1	3
Ethanol	52	13	35	0	0
Natural gas	76	24	0	0	0
Petroleum	84	12	1	1	2
Wood, pine	49	6	45	0	0

Table 1. Chemical compositions, in weight percent, of representative samples of the major fuels.

The transformations of carbon in nature are conveniently summarized in a diagram of the global carbon cycle, see Figure 1. The **global carbon cycle** establishes the **fluxes** of carbon among various sources that introduce carbon into the total environment, and among **sinks**, which remove or **sequester** carbon. An understanding of the directions of flow and annual fluxes among the sources and sinks has become especially important in recent decades, with increasing concern and focus on atmospheric carbon dioxide concentration and its **consequence** for global climate change.

For the global carbon cycle to be at steady state, the **rates** of removing CO_2 from the atmosphere and adding it to the atmosphere must be equal. The important step for CO_2 removal is photosynthesis. CO_2 returns to the atmosphere from burning biomass or biofuels, **decay** of organic matter, and burning fossil fuels. When the flux of carbon dioxide into the atmosphere **exceeds** the flux of carbon into the sinks, concentration of CO_2 in the atmosphere necessarily must increase. A wealth of **solid evidence** shows that atmospheric CO_2 has been increasing for some time. Carbon fluxes from the sources are indeed **outrunning** fluxes back into the sinks.

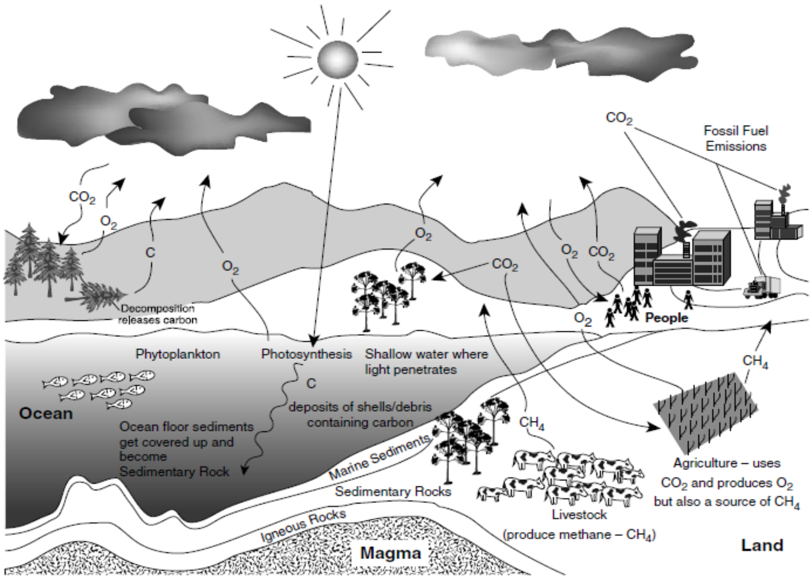

Figure 1. The global carbon cycle.

In recent decades, multiple, independent observations from geology, meteorology, and biology show that **profound changes** are occurring on the planet. These observations include partial melting of the polar ice caps, **shrinkage of glaciers**, increasing **desertification**, spreading of tropical diseases, and setting of new records for high temperatures and for **frequency** of severe storms. All of these observations are **consistent with** the notion that our planet is warming.

The principal source of warmth on Earth is incoming radiation from the sun. To maintain a heat balance, heat is radiated from Earth back into space, largely as infrared radiation. Carbon dioxide is one of a number of gases, others including **water vapor**, methane, **nitrous oxide**, and **chlorofluorocarbons**, that trap infrared. Increasing atmospheric CO_2 concentration acts to retain more heat, by reducing the amount of infrared energy radiated back to space. Hence increasing CO_2 is connected with increasing warming.

The increase in atmospheric CO_2 began at about the same time as the Industrial Revolution, which marked the beginning of large-scale use of fossil fuels. It took millions of years to form fossil fuels. We have been burning them on a large, and ever-increasing, scale only for about 250 years. Thus, the rate of CO_2 addition to the atmosphere currently outstrips the rate of CO_2 removal. **Buttressing** this **circumstantial evidence**, recent years have seen further evidence added for a link between increased atmospheric carbon dioxide and human use of fossil fuels. Certainly, anthropogenic CO_2 emissions from fossil fuel combustion are not the **sole cause** of global warming. Nevertheless, connections between global warming, atmospheric CO_2, and fossil fuel use confront us with several energy policy options. One, of course, is to do nothing. At the other end of the spectrum lies the argument that we must stop using fossil fuels right now.

History teaches us that some 60 to 70 years are needed for one fuel to replace another as the dominant energy source. In 1830, **renewable fuels** (mainly wood) dominated worldwide primary energy sources, accounting for more than 90% of total energy. Coal made up most of the rest. By 1900, the contribution from wood had dropped, and that of coal had increased, to a point at which both energy sources were accounting for nearly 50% of world energy use, with a very small **contribution** from petroleum. Coal dominated the world energy scene until 1965, when coal and petroleum each contributed about 30%, with natural gas and renewables about 15% each. Since 1965 petroleum has dominated the world energy scene. Perhaps at the end of another 70 year cycle, sometime around 2035, we will witness a **resurgence** of renewable energy sources, not just biomass, but also solar, wind, and other forms that do not involve combustion.

It is likely that we are now somewhere in the "**transition state**" between an energy economy heavily dominated by fossil fuels and a new one based on alternative energy sources. Plants, or fuels derived from plants, will contribute to the alternative energy mix. We need to understand the chemistry of these biofuels, but also to recognize that fossil fuels will be with us for decades to come, so we should be concerned with their conversion to clean, efficient fuel forms. Furthermore, we should recognize that, at the end of the transition, fossil fuels will be important sources of graphite, activated carbon, and other carbon-based materials.

X. Answer the following questions:

1. What are fuels?
2. Why can it be advantageous first to carry out one or more processing steps on a fuel before it is burned?
3. What do the uses and behavior of fuels during conversion or utilization processes depend on?
4. What does the global carbon cycle establish?
5. What do multiple independent observations from geology, meteorology, and biology show in recent decades?
6. How is increasing CO_2 connected with increasing warming?
7. How many years are needed for one fuel to replace another as the dominant energy source?
8. What is the "transition state" we are now in?

XI. Look at the energy resources of the earth given in Figure 2 and find the ones that are not mentioned in the text:

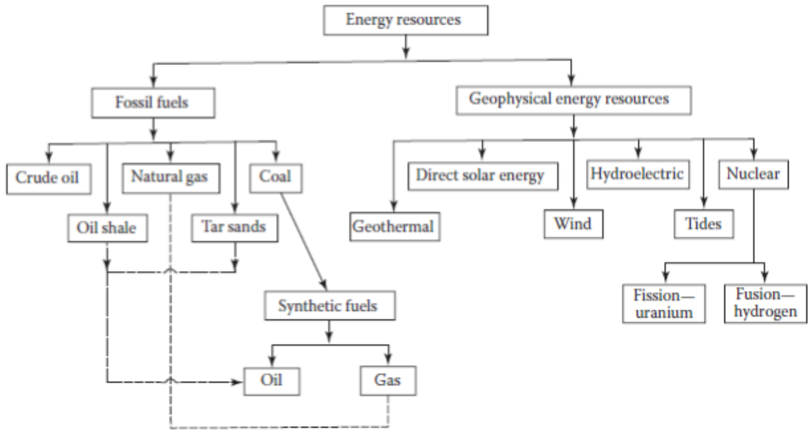

Figure 2. Energy resources of the earth.

XII. Give a short summary of the text according to the basic rules and structure.

UNIT 2 COAL CHEMISTRY AND TECHNOLOGY

Text 1
Chemistry and Major Uses of Coal

1.	**sedimentary rock**	осадочная порода
2.	**swamp**	заболоченная местность
3.	**wet sour gas**	неосушенный сырой газ
4.	**compound**	соединение (химическое); состав
5.	**impurities**	примеси
6.	**ash residue**	зольный остаток
7.	**ash-forming constituent**	золообразующая составная часть (топлива)
8.	**reversibly**	обратимо
9.	**soluble**	растворимый
10.	**dissolution**	растворение
11.	**appreciable amount**	заметное количество
12.	**peat**	торф
13.	**unconsolidated**	незатвердевший
14.	**plant matter**	растительное вещество
15.	**lignite** ['lɪgnaɪt]	лигнит
16.	**rank of coal**	марка угля
17.	**subbituminous coal**	полубитуминозный уголь
18.	**indurated**	затвердевший
19.	**heating value**	энергетическая ценность
20.	**Btu (British Thermal Unit)**	британская тепловая единица 0, 252 ккал
21.	**bituminous coal**	битуминозный уголь; каменный уголь
22.	**anthracite** ['ænθrəsaɪt]	антрацит
23.	**relate to**	относиться к
24.	**minor constituent**	неосновной компонент
25.	**sulfur dioxide**	диоксид серы, сернистый газ
26.	**sulfur trioxide**	триоксид серы; серный газ

27. soot	сажа
28. carbon monoxide	оксид углерода, угарный газ
29. acid rain	кислотный дождь
30. lead	свинец
31. arsenic	мышьяк
32. environmental hazard	экологическая опасность
33. consumer	потребитель
34. pharmaceuticals ['fɑːmə'sjuːtɪk(ə)l]	лекарства
35. coke	кокс
36. fertilizers	удобрения
37. coal tar	битум; каменноугольная смола
38. liquefaction process ['lɪkwɪ'fækʃ(ə)n]	процесс сжижения газа
39. availability	доступность
40. gasification process	процесс газификации
41. synthesis gas	синтетический газ, синтез-газ (смесь водорода и оксида углерода)
42. clean-burning	полностью сгорающий

I. Translate the following international words without a dictionary:

Accumulation, component, individual, contrast, structure, process, electricity, reaction, cement, ceramic.

II. Analyze the formation of degrees of comparison for adjectives from the text and complete the table.

1. Compared to other coal types, anthracite is much ***harder***, and is ***denser*** and ***blacker*** with few impurities.
2. It has a heat value ***higher*** than any form of natural coal.
3. In a liquid or gaseous form, the fuel may be ***easier*** to transport.
4. It is ***the lowest*** rank of coal**.**
5. Anthracite is ***the highest*** grade of coal.

6. ***The largest*** single consumer of coal for this purpose is the electrical power industry.
7. For ***more conventional*** uses of coal, a number of processes have been developed.
8. Lignite is ***the least mature*** of the coal types.
9. Bituminous coal is ***the most common*** coal used around the world.
10. Coal is one of the three ***most important*** fossil fuels for the generation of electricity.
11. By far ***the most important*** properties of coal are the properties that relate to combustion.

	Comparative	Superlative
common		
wide		
long		
different		
soft		
original		
tiny		
wet		
big		

III. Translate the following:

At **least**, **less** than 0.1%, is no **longer** widely used, **the**…**the** (**The** higher the carbon content, **the** more energy the coal contains).

IV. Pay attention to the translation of one in different functions:

1. Coal is ***one*** of the three most important fossil fuels for the generation of electricity.
2. Among the fossil fuels, the progression from natural gas and petroleum to coal is ***one*** of increasing complexity.
3. On a molecular level, petroleum contains thousands of individual compounds, every ***one*** of which could be separated.
4. Coals have a macromolecular structure that varies from ***one*** coal to another.
5. ***One*** must consider the essence of the problem in order to find the appropriate solution.

6. ***One*** day it may be possible to construct gasification systems within a coal mine.
7. On the ***one*** hand, both liquefaction and gasification are attractive technologies because of very large coal resources.
8. Four large hydro units and a few dozen small ***ones*** are currently being constructed.

V. Look at the title of the text and the vocabulary to predict what the text is about.

VI. Skim through the text (= read quickly to get the gist) to check your ideas.

VII. Scan through the text and find out what the following numbers refer to: >90%, 82–87%, 12–15%, 0.1%, 65–95%, 2–6%, 30%, 25%, 70%, 4000–8300, 8,300–13,000, 2–3, 11000–15500, 15000, 1, 0.7.

VIII. Read and translate the following text.

Coal is a black or brownish-black organic **sedimentary rock** that is formed from the accumulation and preservation of plant materials, usually in a **swamp** environment. Coal is a combustible rock, and along with petroleum and natural gas it is one of the three most important fossil fuels for the generation of electricity.

Among the fossil fuels, the progression from natural gas and petroleum to coal is one of increasing complexity. Even a **wet sour gas** has only a small number of possible components. Once the gas has been treated and purified for distribution to consumers, it typically contains >90% of a single **compound**, methane. Gas contains no inorganic **impurities** that might leave an **ash residue** on combustion. Petroleum usually is a homogeneous liquid with a narrow range of elemental composition – about 82–87% carbon, 12–15% hydrogen and the balance nitrogen, sulfur, and oxygen. On a molecular level, petroleum contains thousands of individual compounds, every one of which could be separated, at least in principle, using common techniques of the organic chemistry laboratory, and identified. Inorganic **ash-forming constituents** are commonly less than 0.1%. In contrast, coals have an extremely wide range of composition, some 65–95% carbon, 2–6% hydrogen, up to about 30% oxygen, and possibly several percent each of sulfur and nitrogen.

Coals are heterogeneous solids. Coals cannot be distilled **reversibly**. Coals are not completely **soluble** in any solvent, and even the partial solubility in various solvents is an extraction of components rather than a true, reversible **dissolution** process. Coals have a macromolecular structure that varies from one coal to another. Coals contain a variable, but **appreciable amount** of inorganic material, so that burning a particular coal leaves an ash residue that represents anywhere from a few percent to over 25% of the original weight of the coal. Coals also contain some variable amount of water as they are mined from the Earth, from several percent to about 70%.

The degree of metamorphosis results in differing coal types, each of which has different quality. However, **peat** is not actually a rock but no longer just organic matter and is major source of energy for many nonindustrialized countries. The **unconsolidated plant matter** is lacking the metamorphic changes found in coal. Thus, coal is classified into four main types, depending on the amount of carbon, oxygen, and hydrogen present. The higher the carbon content, the more energy the coal contains.

Lignite (brown coal) is the least mature of the coal types and provides the least yield of energy; it is often crumbly, relatively moist, and powdery. It is the lowest **rank of coal**, with a heating value of 4000–8300 Btu per pound. Lignite is mainly used to produce electricity.

Subbituminous coal is poorly **indurated** and brownish in color, but more like bituminous coal than lignite. It typically contains less **heating value** (8300–13000 Btu per pound) and more moisture than bituminous coal.

Bituminous coal was formed by added heat and pressure on lignite and is the black, soft, slick rock and the most common coal used around the world. Made of many tiny layers, bituminous coal looks smooth and sometimes shiny. It has 2–3 times the heating value of lignite. Bituminous coal contains 11000–15500 Btu per pound. Bituminous coal is used to generate electricity and is an important fuel for the steel and iron industries.

Anthracite is the highest grade of coal and is actually considered to be metamorphic. Compared to other coal types, anthracite is much harder, and is denser and blacker with few impurities. It is largely used for heating domestically as it burns with little smoke. It is deep black and looks almost metallic due to its glossy surface. Like bituminous coal, anthracite coal is a big energy producer, containing nearly 15000 Btu per pound.

By far the most important properties of coal are the properties that **relate to** combustion. When coal is combusted, the two predominant products are carbon dioxide and water. During this chemical reaction, a relatively large amount of heat energy is released. During the combustion of coal, **minor constituents** are also oxidized (i.e., they burn). Sulfur is converted to **sulfur dioxide** and **sulfur trioxide**, and nitrogen compounds are converted to nitrogen oxides. The incomplete combustion of coal and these minor constituents results in a number of environmental problems. For example, **soot** formed during incomplete combustion may settle out of the air and deposit an unattractive coating on homes, cars, buildings, and other structures. **Carbon monoxide** formed during incomplete combustion is a toxic gas and may cause illness or death in humans and other animals. Oxides of sulfur and nitrogen react with water vapor in the atmosphere and then settle out in the air as **acid rain**. Acid rain is responsible for the destruction of certain forms of plants and animals, and fish.

In addition to these compounds, coal often contains a small percentage of mineral matter: quartz, calcite, or perhaps clay minerals. These components do not burn readily and so become part of the ash formed during combustion. This ash then either escapes into the atmosphere or is left in the combustion vessel and must be discarded. Sometimes coal ash also contains significant amounts of **lead**, barium, **arsenic**, or other elements. Whether airborne or in bulk, coal ash can therefore be a serious **environmental hazard**.

Today, the most important use of coal, both directly and indirectly, is still as a fuel, but the largest single **consumer** of coal for this purpose is the electrical power industry. The combustion of coal in power-generating plants is used to make steam, which, in turn, operates turbines and generators.

Although coal is no longer widely used to heat homes and buildings, it is still used in industries such as paper production, cement and ceramic manufacture, iron and steel production, and chemical manufacture for heating and steam generation. It is also an important source of chemicals used to make **pharmaceuticals**, **fertilizers**, pesticides, and other products.

Another use for coal is in the manufacture of **coke**. Coke is nearly pure carbon produced when soft coal is heated in the absence of air. In most cases, 1 ton of coal will produce 0.7 ton of coke in this process. Coke is valuable in industry because it has a heat value higher than any form of natural coal. It is widely used in steelmaking and in certain chemical processes.

In addition, for the more conventional uses of coal for power generation and production of **coal tar** and coke, a number of processes have been developed by which solid coal can be converted to a liquid or gaseous form for use as a fuel. Conversion has a number of advantages. In a liquid or gaseous form, the fuel may be easier to transport. Also, the conversion process removes a number of impurities from the original coal (such as sulfur) that have environmental disadvantages. In the **liquefaction process**, the goal is to convert coal to a petroleum-like liquid that can be used as a fuel for motor vehicles and other applications. On the one hand, both liquefaction and gasification are attractive technologies because of very large coal resources. On the other hand, the wide **availability** of raw coal means that expensive new technologies have been unable to compete economically with the natural product. In the **gasification process**, crushed coal is forced to react with steam and either air or pure oxygen to produce **synthesis gas**, a mixture of carbon monoxide, hydrogen, and methane used directly as fuel or refined into **cleaner-burning** gas. One day it may be possible to construct gasification systems within a coal mine, making it much easier to remove the coal (in a gaseous form) from its original seam.

IX. Answer the following questions:

1. What is coal?
2. How complex are compositions of fossil fuels?
3. How soluble are coals?
4. What does the degree of metamorphosis result in?
5. What are the four main types of coal?
6. What are the most important properties of coal?
7. What are the main uses of coal?
8. How is synthesis gas produced?

X. Give a short summary of the text according to the basic rules and structure.

Text 2
Clean Coal Technologies

1.	**emission**	выброс (газ. отходов)
2.	**deleterious** ['delɪ'tɪərɪəs]	вредоносный; опасный
3.	**obnoxious**	наносящий ущерб; причиняющий вред; вредный
4.	**acceptability**	приемлемость; соответствие требованиям
5.	**clean coal technology**	экологически чистая технология использования угля
6.	**pollutant**	загрязнитель, загрязняющее вещество
7.	**treatment**	технологическая обработка
8.	**combustion efficiency**	полнота сгорания топлива
9.	**pollution control**	контроль загрязнения (окружающей среды)
10.	**transport fuel**	транспортное топливо
11.	**facilitate**	способствовать
12.	**capture**	улавливание, захват
13.	**combustion effluent**	отходы горения
14.	**integrated gasification combined-cycle**	комбинированный цикл с газификацией угля
15.	**heat recovery system**	система регенерации тепла
16.	**geosequestration**	геологическая секвестрация (долгосрочное захоронение CO2 в различных глубоких геологических образованиях)
17.	**purification**	очистка
18.	**exhaust stream**	поток выхлопных газов
19.	**flue gas**	отработанный газ, отходящий газ
20.	**coal washing**	обогащение угля, промывка угля
21.	**particulates**	твёрдые частицы (в газах)
22.	**wet scrubber**	мокрый газоочиститель, мокрый золоуловитель
23.	**flue gas desulfurization**	обессеривание дымовых газов

24. drywall	гипсокартон
25. ground-level ozone	приповерхностный озон
26. electrostatic precipitators	электрофильтр
27. collection plate	осадительный пластинчатый электрод (электрофильтра)
28. pressurized air	сжатый воздух
29. zero emissions	нулевые выбросы
30. greenhouse gas emissions	выбросы парниковых газов в атмосферу

I. Translate the following:

Resulting from, in this respect, for this reason, divided into, pre- or post combustion, relating to, comparable to, as a means of, with … in mind, , followed by, not only … but also, either … or, so as to, known as, such as.

II. Analyze the suffixes of the following words and match the latter to the corresponding part of speech:

NOUN	VERB	ADJECTIVE	ADVERB

Deleterious. pollutant, criticize, gaseous, reduce, acceptability, collectively, environmental, broadly, treatment, produce, comparable, currently, generate, generator, purify, respiratory, mixture, aggravate.

III. Translate the following attributive chains:

Heat energy, gas turbine, steam turbine, coal extraction, coal gasification, gasification process, electricity generation, combustion efficiency, efficiency improvements, emissions reduction, cement manufacturing, greenhouse gas emissions, fossil fuel burning, coal-fired power stations, secondary steam-powered generator, power generation plant design, postcombustion carbon dioxide capture technology.

IV. Pay attention to the translation of Participle I:

1. Emissions ***resulting*** from the use of the various fossil fuels have had deleterious effects on the environment.

2. The term has been criticized as ***being*** misleading.
3. Clean coal technologies may be broadly divided into processes ***relating*** either to (1) combustion efficiency or (2) pollution control.
4. The ***resulting*** hydrogen gas can be used for electricity generation or as a transport fuel.
5. The systems combine gasification with a heat recovery system, thereby ***increasing*** the power generated from a given amount of coal.
6. One main advantage of this process is to separate hexane, thus ***preventing*** the formation of benzene.
7. Many metallic elements are found in crude oils, ***including*** most of those that occur in seawater.

V. Look at the title of the text and the vocabulary to predict what the text is about.

VI. Skim through the text (= read quickly to get the gist) to check your ideas.

VII. Scan through the text and find out what the following abbreviations stand for: CCT, IGCC, CCS, FGD.

VIII. Read and translate the following text.

Emissions resulting from the use of the various fossil fuels have had **deleterious** effects on the environment unless adequate curbs are taken to control not only the nature but also the amount of gaseous products being released into the atmosphere. In this respect, coal is often considered to be a *dirty* fuel and is usually cited as the most environmentally **obnoxious** of the fossil fuels.

There are a number of processes that are being used in coal-fired power stations that improve the efficiency and environmental **acceptability** of coal extraction, preparation and use, and many more are under development. These processes are collectively known as ***clean coal technologies*** *(CCT)*. Designation of a technology as a *clean coal technology* does not imply that it reduces emissions to zero or near zero. For this reason, the term has been criticized as being misleading; it might be more appropriate to refer to *cleaner coal technologies*.

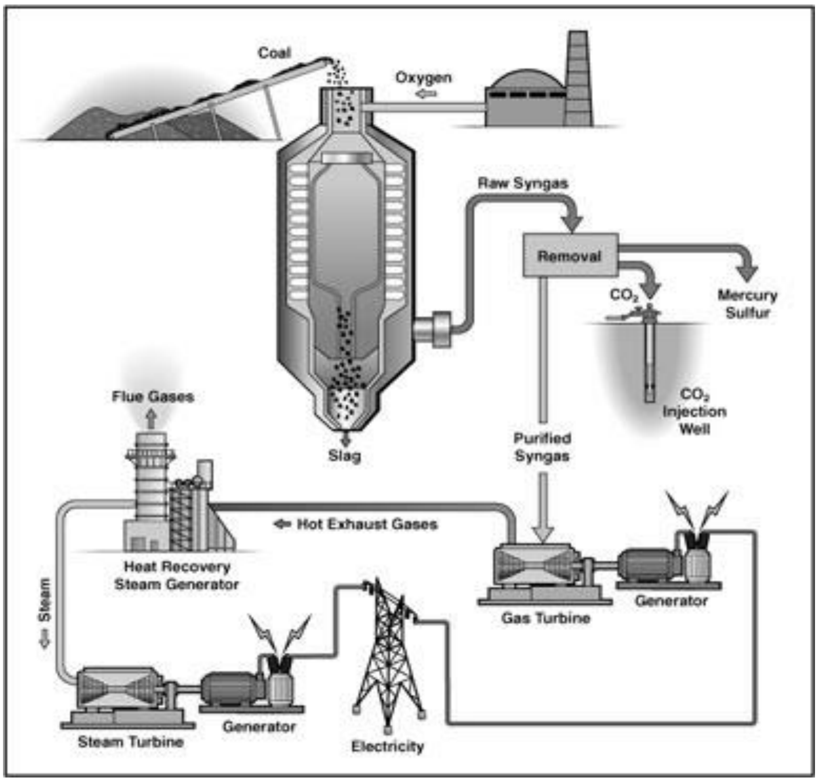

Figure 3. Clean coal technology.

Nevertheless, *clean coal technologies* reduce emissions of several **pollutants**, reduce waste, and increase the amount of energy gained from each ton of coal. They include various chemical and physical **treatments** applied pre- or post combustion and may be broadly divided into processes relating either to (1) **combustion efficiency** or (2) **pollution control**.

An example is gasification of coal by burning it in oxygen to produce a cleaner gaseous fuel known as *syngas* or *synthesis gas*, which is comparable in its combustion efficiency to natural gas. This reduces the emissions of sulfur, nitrogen oxides, and mercury, resulting in a much cleaner fuel. The resulting hydrogen gas can be used for electricity generation or as a **transport fuel**. The gasification process also

facilitates capture of carbon dioxide emissions from the **combustion effluent**.

Integrated gasification combined-cycle (IGCC) systems combine gasification with a **heat recovery system** that feeds a secondary steam-powered generator, thereby increasing the power generated from a given amount of coal. These systems are currently being employed in many new coal-fired power plants worldwide.

CCS (carbon capture and storage) is a technology that offers much higher prospects of emissions reductions than other clean coal technologies. CCS involves capture of carbon dioxide either before or after combustion of the fuel; transport of the captured carbon dioxide to the site of storage; and injection of the carbon dioxide in deep underground reservoirs for long-term storage (**geosequestration**). CCS is proposed as a means of reducing to near-zero the greenhouse gas emissions of fossil fuel burning in power generation and carbon dioxide production from other industrial processes such as cement manufacturing and **purification** of natural gas. Many clean coal technologies are being developed with CCS in mind, for example, concentrating carbon dioxide in the combustion exhaust to ease the separation and capture of carbon dioxide. The majority of the CCS effort is being invested in incorporating CCS into new power generation plant designs—current figures indicate that it is cheaper to build a new IGCC plant that produces a pure carbon dioxide **exhaust stream** than to retrofit an existing plant with postcombustion carbon dioxide capture technology.

Clean coal technologies seek to reduce harsh environmental effects by using multiple technologies to clean coal and contain its emissions.

When coal burns, it releases carbon dioxide and other emissions in **flue gas**. Some clean coal technologies purify the coal before it burns. One type of coal preparation, **coal washing**, removes unwanted minerals by mixing crushed coal with a liquid and allowing the impurities to separate and settle.

Other systems control the coal burn to minimize emissions of sulfur dioxide, nitrogen oxides, and **particulates**. ***Wet scrubbers***, or **flue gas desulfurization** (FGD) systems, remove sulfur dioxide, a major cause of acid rain, by spraying flue gas with limestone and water. The mixture reacts with the sulfur dioxide to form synthetic gypsum, a component of **drywall**.

Low-NOx (nitrogen oxide) burners reduce the creation of nitrogen oxides, a cause of **ground-level ozone**, by restricting oxygen and manipulating the combustion process. ***Electrostatic precipitators*** remove particulates that aggravate asthma and cause respiratory ailments by charging particles with an electrical field and then capturing them on **collection plates**.

Gasification avoids burning coal altogether. With IGCC systems, steam and hot **pressurized air** or oxygen combine with coal. The resulting *synthesis gas* (*syngas*), a mixture of carbon monoxide and hydrogen, is then cleaned and burned in a gas turbine to make electricity. The heat energy from the gas turbine also powers a steam turbine. Since IGCC power plants create two forms of energy, they have the potential to reach a fuel efficiency of 50%.

The clean coal technology field is moving in the direction of coal gasification with a second stage so as to produce a concentrated and pressurized carbon dioxide stream followed by its separation and geological storage. This technology has the potential to provide what may be called ***zero emissions*** — but which, in reality, are extremely low emissions of the conventional coal pollutants.

This has come about as a result of the realization that efficiency improvements, together with the use of natural gas and renewables such as wind, will not provide the deep cuts in **greenhouse gas emissions** necessary to meet future national targets.

IX. Answer the following questions:

1. What effects do emissions from the use of fossil fuels have on the environment?
2. What is coal often considered to be?
3. What do clean coal technologies reduce?
4. What systems are currently being employed in many new coal-fired power plants worldwide?
5. Why does carbon capture and storage technology offer much higher prospects of emissions reductions than other clean coal technologies?

X. Give a short summary of the text according to the basic rules and structure.

UNIT 3 PETROLEUM CHEMISTRY AND TECHNOLOGY

Text 1
Chemistry and Major Uses of Petroleum

1.	**petroleum**	нефть
2.	**crude oil**	неочищенная сырая нефть
3.	**bitumen** ['bɪtjumɪn]	битум, битуминозная нефть, горная смола
4.	**viscous** ['vɪskəs]	вязкий
5.	**tar sands**	нефтеносные пески
6.	**constitute**	составлять, образовывать
7.	**intimately associated**	неразрывно связанный
8.	**treatise** ['tri:tɪs]	трактат, научный труд
9.	**hydrogen** ['haɪdrəʤ(ə)n]	водород
10.	**by weight**	по массе
11.	**alkenes** [ˈæl.ki:nz]	алкены, ненасыщенные углеводороды
12.	**bond**	связь
13.	**aromatics**	ароматические углеводороды
14.	**alkanes** ['ælkeinz]	алканы, насыщенные углеводороды
15.	**paraffinic series**	парафиновый ряд (углеводородов)
16.	**gasoline** ['gæsəli:n]	бензин
17.	**paraffin waxes**	твёрдые парафины, парафиновые воски
18.	**naphthenic series**	нафтеновый ряд (углеводородов)
19.	**refinery products**	продукты переработки
20.	**asphalt-base crude**	нефть асфальтового основания
21.	**aromatic series**	ароматический ряд (углеводородов)
22.	**specific gravity**	удельная плотность
23.	**corrosive agent**	источник коррозии
24.	**sodium chloride**	хлористый натрий
25.	**decay-resistant organic remains**	органические остатки, устойчивые к гниению
26.	**siliceous** [sɪ'lɪʃəs]	кремнесодержащий

I. Match the words and phrases from the text to the necessary prepositions in the table and translate them:

to	in	of	into	from	for	with	between … and …	from … to	in … to

1. refer …
2. be attributed …
3. published …
4. regardless …
5. be restricted …
6. be grouped …
7. range ….
8. be divided …
9. boil …
10. be present …
11. … addition …
12. … this reason
13. be associated …
14. consist …
15. due …
16. be removed …
17. vary …

II. Analyze the formation of the following compound nouns and translate them:

closed-ring series
asphalt-base crudes
lower-density paraffins
boiling-point ranges
single-bond hydrocarbons
decay-resistant organic remains
six-ring carbon-hydrogen bonds

III. Give the forms of the following irregular verbs:

INFINITIVE	PAST SIMPLE	PARTICIPLE II
know		
find		
have		
break		
drive		
send		
meet		
make		
come		
feed		
sink		

put		
lose		

IV. Pay attention to the translation of Participle II:

1. The residues ***obtained*** by refining lower-density paraffins are both plastic and solid paraffin waxes.
2. The first use of the word petroleum was in a treatise ***published*** in 1556 by the German mineralogist Georg Bauer, ***known*** as Georgius Agricola.
3. Crude oil is an organic compound ***divided*** primarily into alkenes or aromatics.
4. Sulfur oxides ***released*** into the atmosphere during the combustion of oil would constitute a major pollutant.
5. The naphthenic series is a ***saturated*** closed-ring series.
6. The processes remove harmful or ***unwanted*** compounds such as metals, sulfur, nitrogen, and oxygen.
7. The ***produced*** naphtha reformate has a much higher octane number than the feed.
8. In the crude state, petroleum has minimal value, but when ***refined***, it provides high-value liquid fuels, solvents, lubricants, and many other products.

V. Look at the title of the text and the vocabulary to predict what the text is about.

VI. Skim through the text (= read quickly to get the gist) to check your ideas.

VII. Scan through the text and find out the following information:

- the meaning of the Latin *petra*
- the real name of Georgius Agricola
- the general formula of the naphthenic series
- the sulfure content of Mexican and Mississippi oils
- the most common metallic elements in oil

VIII. Read and translate the following text.

Petroleum is a complex mixture of hydrocarbons that occur in Earth in liquid, gaseous, or solid form. The term is often restricted to the liquid form, commonly called **crude oil**, but, as a technical term, *petroleum* also refers to natural gas and the **viscous** or solid form known as **bitumen**, which is found in **tar sands**. The liquid and gaseous phases of petroleum **constitute** the most important of the primary fossil fuels.

Liquid and gaseous hydrocarbons are so **intimately associated** in nature that it has become customary to shorten the expression "petroleum and natural gas" to "petroleum" when referring to both. The first use of the word *petroleum* (literally "rock oil" from the Latin *petra*, "rock" or "stone," and *oleum*, "oil") is often attributed to a **treatise** published in 1556 by the German mineralogist Georg Bauer, known as Georgius Agricola. However, there is evidence that it may have originated with Persian philosopher-scientist Avicenna some five centuries earlier.

Chemical composition

Hydrocarbon content

Although oil consists basically of compounds of only two elements, carbon and **hydrogen**, these elements form a large variety of complex molecular structures. Regardless of physical or chemical variations, however, almost all crude oil ranges from 82 to 87 percent carbon **by weight** and 12 to 15 percent hydrogen. The more viscous bitumens generally vary from 80 to 85 percent carbon and from 8 to 11 percent hydrogen.

Crude oil is an organic compound divided primarily into **alkenes** with single-**bond** hydrocarbons of the form C_nH_{2n+2} or **aromatics** having six-ring carbon-hydrogen bonds, C_6H_6. Most crude oils are grouped into mixtures of various and seemingly endless proportions. No two crude oils from different sources are completely identical.

The **alkane paraffinic series** of hydrocarbons, also called the methane (CH_4) series, comprises the most common hydrocarbons in crude oil. The major constituents of **gasoline** are the paraffins that are liquid at normal temperatures but boil between 40 °C and 200 °C (100 °F and 400 °F). The residues obtained by refining lower-density paraffins are both plastic and solid **paraffin waxes**.

The **naphthenic series** has the general formula C_nH_{2n} and is a saturated closed-ring series. This series is an important part of all liquid **refinery products**, but it also forms most of the complex residues from the higher boiling-point ranges. For this reason, the series is generally heavier. The residue of the refining process is asphalt, and the crude oils in which this series predominates are called **asphalt-base crudes**.

The **aromatic series** is an unsaturated closed-ring series. Its most common member, benzene (C_6H_6), is present in all crude oils, but the aromatics as a series generally constitute only a small percentage of most crudes.

Nonhydrocarbon content

In addition to the practically infinite mixtures of hydrocarbon compounds that form crude oil, sulfur, nitrogen, and oxygen are usually present in small but often important quantities. Sulfur is the third most abundant atomic constituent of crude oils. It is present in the medium and heavy fractions of crude oils. In the low and medium molecular ranges, sulfur is associated only with carbon and hydrogen, while in the heavier fractions it is frequently incorporated in the large polycyclic molecules that also contain nitrogen and oxygen. The total sulfur in crude oil varies from below 0.05 percent (by weight), as in some Venezuelan oils, to about 2 percent for average Middle Eastern crudes and up to 5 percent or more in heavy Mexican or Mississippi oils. Generally, the higher the **specific gravity** of the crude oil (which determines whether crude is heavy, medium, or light), the greater its sulfur content. The excess sulfur is removed from crude oil prior to refining, because sulfur oxides released into the atmosphere during the combustion of oil would constitute a major pollutant, and they also act as a significant **corrosive agent** in and on oil processing equipment.

The oxygen content of crude oil is usually less than 2 percent by weight and is present as part of the heavier hydrocarbon compounds in most cases. For this reason, the heavier oils contain the most oxygen. Nitrogen is present in almost all crude oils, usually in quantities of less than 0.1 percent by weight. **Sodium chloride** also occurs in most crudes and is usually removed like sulfur.

Many metallic elements are found in crude oils, including most of those that occur in seawater. This is probably due to the close association between seawater and the organic forms from which oil is generated. Among the most common metallic elements in oil are vanadium and nickel, which apparently occur in organic combinations as they do in living plants and animals.

Crude oil also may contain a small amount of **decay-resistant organic remains**, such as **siliceous** skeletal fragments, wood, spores, resins, coal, and various other remnants of former life.

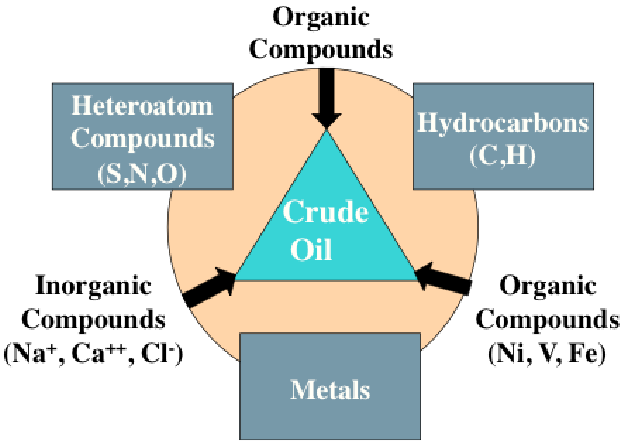

Figure 4. Constituents of crude oil.

IX. Answer the following questions:

1. What is petroleum?
2. Where was the word petroleum first used?
3. What is the hydrocarbon content of crude oil?
4. What is crude oil as an organic compound primarily divided into?
5. Are crude oils from different sources completely identical?
6. What is the nonhydrocarbon content of crude oil?
7. What are the most common metallic elements in oil?

X. Give a short summary of the text according to the basic rules and structure.

Text 2
Introduction to Refining Processes

1.	**lubricant**	смазочный материал
2.	**approximately**	приблизительно
3.	**diesel fuel**	дизельное топливо
4.	**by-product**	побочный продукт
5.	**waterproofing**	гидроизоляция
6.	**seepage**	выход нефти на поверхность
7.	**volatile**	летучий
8.	**processing unit**	технологическая установка
9.	**auxiliary facility**	вспомогательные сооружения
10.	**utility units**	подсобные помещения
11.	**storage tanks**	резервуары для хранения
12.	**catalytic conversion**	каталитическое преобразование, каталитическая конверсия
13.	**petroleum refinery**	нефтеперерабатывающий завод
14.	**catalytic reforming**	каталитический риформинг риформинг под воздействием катализатора
15.	**catalyst**	катализатор
16.	**supported on**	на основе из, нанесённый на
17.	**silica**	кремнезём (двуокись кремния)
18.	**alumina** [ə'l(j)u:mɪnə]	окись алюминия; глинозём
19.	**reformate**	продукт риформинга
20.	**octane number**	октановое число
21.	**benzene–toluene–xylene** ['benzi:n,ben'zi:n]- ['tɑljʊi:n]- ['zaili:n]	бензол-толуол-ксилол(ароматические углеводороды)
22.	**hydrotreating**	гидроочистка
23.	**oxy-compounds**	оксисоединения
24.	**alumina matrix**	матрица из оксида алюминия
25.	**catalytic hydrocracking**	каталитический гидрокрекинг
26.	**atmospheric residue**	остаток атмосферной перегонки

27.	**vacuum gas oil**	вакуумный газойль; газойль, полученный вакуумной перегонкой
28.	**dual function catalyst**	бифункциональный катализатор
29.	**zeolite catalyst** ['ziːəlaɪt]	цеолитный катализатор
30.	**rare earth metals**	редкоземельные металлы
31.	**hydrogenation**	гидрогенизация, наводораживание
32.	**catalytic cracking**	каталитический крекинг, каталитическое расщепление
33.	**fluid catalytic cracking**	крекинг с флюидизированным катализатором, флюид-каталитический крекинг
34.	**refinery gas**	газ нефтепереработки
35.	**alkylation**	алкилирование
36.	**gasoline range alkylate**	алкилат бензинового ряда
37.	**sulphuric acid**	серная кислота
38.	**hydrofluoric acid**	фтороводородная кислота
39.	**delayed coker**	установка коксования замедленного действия
40.	**isomerization** [aɪˌsɒməraɪ'zeɪʃn]	изомеризация
41.	**carcinogenic** ['kɑːsɪnə'ʤenɪk]	канцерогенный
42.	**carbon rejection**	удаление углерода
43.	**flexicoking**	флексикокинг
44.	**visbreaking**	висбрекинг; вторичная перегонка нефти
45.	**pour point**	температура застывания/точка потери текучести

I. Match the two halves to make collocations from the text and translate them:

1. in the crude	a) products
2. have minimal	b) sense
3. a wide	c) considerations
4. in a very general	d) process
5. prior	e) state
6. thermal	f) variety

7. marketable	g) phase
8. industrial	h) to use
9. economic	i) complexes
10. in liquid	j) value

II. Analyze the formation of the following compound nouns and translate them:

transportation fuels
premium value product
high-value liquid fuels
total world energy supply
once-maligned by-product
high octane number products
near-solid machinery lubricants

III. Pay attention to the translation of the Gerund:

1. For higher molecular weight fractions, ***cracking*** in the presence of hydrogen is required to get light products.
2. Conversion of heavy oils to useful products requires ***breaking*** or ***cracking*** of large molecules into smaller ones.
3. The world is not on the verge of ***running*** out of petroleum.
4. This type of refinery is capable of ***supplying*** the traditional refined products.
5. ***Processing*** consists of ***separating*** all of the various hydrocarbons and fluids from the pure natural gas.
6. The actual practice of ***processing*** natural gas to pipeline dry gas quality levels can be quite complex.

IV. Look at the title of the text and the vocabulary to predict what the text is about.

V. Skim through the text (= read quickly to get the gist) to check your ideas.

VI. Scan through the text and find out the following abbreviations stand for: BTX, AR,VGO, FCC.

VII. Read and translate the following text.

In the crude state, petroleum has minimal value, but when refined, it provides high-value liquid fuels, solvents, **lubricants**, and many other products. The fuels derived from petroleum contribute **approximately** one-third to one-half of the total world energy supply and are used not only for transportation fuels (i.e., gasoline, **diesel fuel**, and aviation fuel, among others) but also to heat buildings. Petroleum products have a wide variety of uses that vary from gaseous and liquid fuels to near-solid machinery lubricants. In addition, the residue of many refinery processes, asphalt — a once-maligned **by-produc**t—is now a premium value product for highway surfaces, roofing materials, and miscellaneous **waterproofing** uses.

In a very general sense, petroleum refining can be traced back over 5000 years to the times when asphalt materials and oils were isolated from areas where natural **seepage** occurred. Any treatment of the asphalt (such as hardening in the air prior to use) or of the oil (such as allowing for more **volatile** components to escape prior to use in lamps) may be considered to be refining under the general definition of refining. However, petroleum refining as we know it is a very recent science and many innovations evolved during the twentieth century. Briefly, petroleum refining is the separation of petroleum into fractions and the subsequent treating of these fractions to yield marketable products.

Petroleum refineries are very large industrial complexes that involve many **processing units** and **auxiliary facilities** such as **utility units** and **storage tanks**. Some modern petroleum refineries process as much as 900 000 barrels per day of crude oil. Each refinery has its own unique arrangement and combination of refining processes largely determined by the refinery location, desired products, and economic considerations.

Conversion of heavy oils to useful products requires breaking or cracking of large molecules into smaller ones by separation and chemical reaction processes. In the processes, harmful or unwanted compounds such as metals, sulfur, nitrogen, and oxygen are also removed.

These processes are briefly characterized as follows:

Physical separation	Chemical conversion	
	Catalytic	Thermal
Distillation	Reforming	Delayed coking
Solvent deasphalting	Hydrotreating	Flexicoking
Solvent extraction	Hydrocracking	Visbreaking
Solvent dewaxing	Alkylation	
	Isomerization	

Table 2. Major refining processes in modern refineries.

Chemical Catalytic Conversion Processes

Catalytic Reforming

In this process a special **catalyst** (platinum metal **supported on silica** or silica base **alumina**) is used to restructure naphtha fraction (C6–C10) into aromatics and isoparaffins. The produced naphtha **reformate** has a much higher **octane number** than the feed. This reformate is used in gasoline formulation and as a feedstock for aromatic production (**benzene–toluene–xylene**, BTX).

Hydrotreating

This is one of the major processes for the cleaning of petroleum fractions from impurities such as sulphur, nitrogen, **oxy-compounds**, chlorocompounds, aromatics, waxes and metals using hydrogen. The catalyst is selected to suit the degree of hydrotreating and type of impurity. Catalysts, such as cobalt and molybdenum oxides on **alumina matrix**, are commonly used.

Catalytic Hydrocracking

For higher molecular weight fractions such as **atmospheric residues** (AR) and **vacuum gas oils** (VGOs), cracking in the presence of hydrogen is required to get light products. In this case a **dual function catalyst** is used. It is composed of a **zeolite catalyst** for the cracking function and **rare earth metals** supported on alumina for the **hydrogenation** function. The main products are kerosene, jet fuel, diesel and fuel oil.

Catalytic Cracking

Fluid catalytic cracking (FCC) is the main player for the production of gasoline. The catalyst in this case is a zeolite base for the cracking function. The main feed to FCC is VGO and the product is gasoline, but some gas oil and **refinery gases** are also produced.

Alkylation

Alkylation is the process in which isobutane reacts with olefins such as butylene (C4) to produce a **gasoline range alkylate**. The catalyst in this case is either **sulphuric acid** or **hydrofluoric acid**. The hydrocarbons and acid react in liquid phase. Isobutane and olefins are collected mainly from FCC and **delayed coker**.

Isomerization

Isomerization of light naphtha is the process in which low octane number hydrocarbons (C4, C5, C6) are transformed to a branched product with the same carbon number. This process produces high octane number products. One main advantage of this process is to separate hexane (C6) before it enters the reformer, thus preventing the formation of benzene which produces **carcinogenic** products on combustion with gasoline. The main catalyst in this case is a Pt-zeolite base.

Thermal Chemical Conversion Processes

These processes are considered as upgrading processes for vacuum residue.

Delayed Coking

This process is based on the thermal cracking of vacuum residue by **carbon rejection** forming coke and lighter products such as gases, gasoline and gas oils. Three types of coke can be produced: sponge, shot and needle. The vacuum residue is heated in a furnace and flashed into large drums where coke is deposited on the walls of these drums, and the rest of the products are separated by distillation.

Flexicoking

In this thermal process, most of the coke is gasified into fuel gas using steam and air. The burning of coke by air will provide the heat required for thermal cracking. The products are gases, gasoline and gas oils with very little coke.

Visbreaking

This is a mild thermal cracking process used to break the high viscosity and **pour points** of vacuum residue to the level which can be used in further downstream processes. In this case, the residue is either broken in the furnace coil (coil visbreaking) or soaked in a reactor for a few minutes (soaker visbreaker). The products are gases, gasoline, gas oil and the unconverted residue.

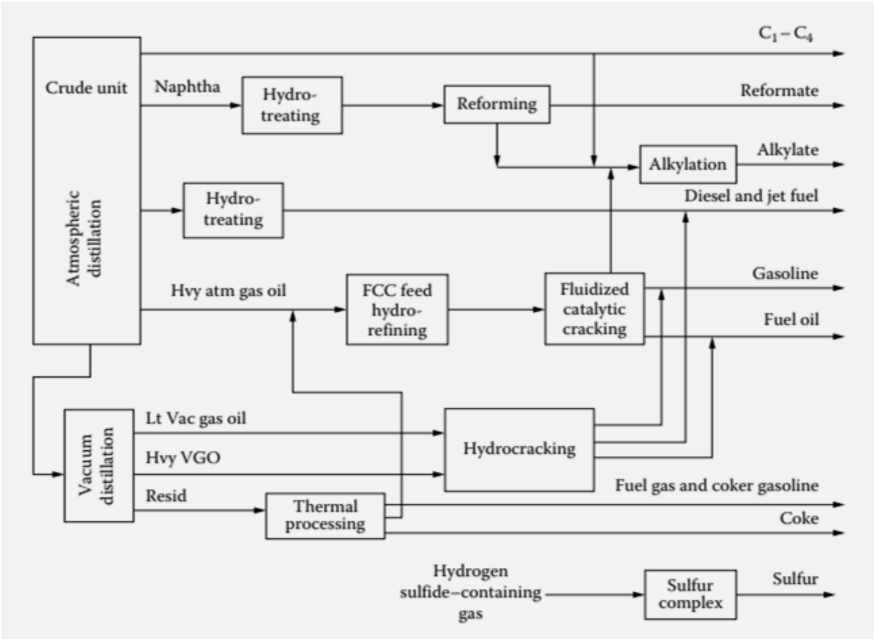

Figure 4. Schematic overview of a refinery.

VIII. Answer the following questions:

1. How valuable is petroleum in the crude state?
2. What residue of many refinery processes was a once-maligned by-product?
3. How old is petroleum refining?
4. What are petroleum refineries like?
5. What is removed in the processes of heavy oils conversion?
6. What are chemical catalytic conversion processes?
7. What are thermal chemical conversion processes?

IX. Give a short summary of the text according to some basic rules and structure:

Text 3
Refining in the Future

1.	**peak oil**	пик добычи нефти
2.	**price fluctuations**	динамика цен
3.	**tight formation**	пласт с малой проницаемостью
4.	**vehicle fuel**	моторное топливо
5.	**ultimate amounts**	максимальное количество
6.	**environmental compliance**	экологическая безопасность
7.	**environmentally friendly**	экологически безопасный; экологически чистый
8.	**process configuration**	технологическая конфигурация
9.	**product slate**	линейка продукции
10.	**petrochemical processing**	нефтехимическая обработка
11.	**subterranean**	находящийся в недрах земли, подземный
12.	**end use consumer**	конечный потребитель
13.	**imperative**	крайне важный; крайне необходимый
14.	**performance goals**	производственные цели
15.	**profitability**	прибыльность; рентабельность
16.	**survivability**	жизнеспособность, устойчивость
17.	**heavy ends deep conversion**	глубокая переработка тяжелых фракций
18.	**oil shale**	нефтеносный сланец
19.	**fouling**	загрязнение
20.	**meet specifications**	соответствовать техническим условиям
21.	**petrochemical intermediates**	промежуточные продукты нефтехимии
22.	**integrated gasification combined cycle**	комбинированный цикл комплексной газификации
23.	**cracked residua**	крекинговый остаток
24.	**resilient**	устойчивый
25.	**commence operations**	начинать работу, деятельность

I. Analyze the formation of the following words and translate them:

Underground, oil-producing, ultraclean, hydrocracking, hydrotreating, environmentally, subterranean.

II. Match the words and phrases to their Russian equivalents:

1. in spite of	a) способный к
2. on the verge of	b) спрос на
3. run out of	c) в соответствии с
4. demand for	d) в любом случае
5. according to	e) на грани
6. in exactly the same way	f) а не, скорее ... чем
7. in excess of	g) прежде всего
8. in response to	h) полностью
9. all the way through	i) заканчиваться, иссякать (о запасах и т. п.)
10. adaptive to	j) точно таким же образом
11. above all	k) несмотря на
12. rather than	l) отвечающий требованиям к, совместимый
13. capable of	m) свыше; сверх
14. compatible with	n) легко приспосабливающийся к
15. anyway	o) как реакция на

III. Translate the underlined parts paying attention to as in different functions:

1. Cheap petroleum may be a problem in the future ***as*** recent price fluctuations have indicated.
2. ***As*** feedstocks to refineries change, there must be an accompanying change in the refinery technology.
3. … changing requirements such ***as*** (1) a demand for gasoline and diesel fuel ***as*** well ***as*** fuel oil, (2) petrochemicals ***as*** building blocks for clothing and consumer goods, and ….
4. ***As*** a result of this response, the production facilities within the refining industry have become increasingly diverse.

IV. Pay attention to the translation of Modal Verbs and their equivalents:

1. Cheap petroleum ***may*** be a problem in the future as recent price fluctuations have indicated.
2. As feedstocks to refineries change, there ***must*** be an accompanying change in the refinery technology.
3. The refining industry ***can*** be regarded as unique insofar as very few industries ***have to*** deal with a feedstock-product chain beginning at a natural resource that ***has to*** be recovered from a subterranean formation and proceed through the application of a variety of processes all the way through to the end use consumer.
4. It will be necessary to explore the means by which the technology and methodology of refinery operations ***can*** be translated not only into increased profitability but also into survivability.
5. Above all, such feedstock ***must*** be compatible with refinery feedstocks.
6. The panacea for a variety of feedstocks ***could*** well be the gasification refinery.
7. Integrated gasification combined cycle (IGCC) ***can*** be used to raise power from feedstocks.

V. Look at the title of the text and the vocabulary to predict what the text is about.

VI. Skim through the text (= read quickly to get the gist) to check your ideas.

VII. Scan through the text and find 5 aspects of the petroleum technology that large integrated oil companies are engaged in:

VIII. Read and translate the following text.

In spite of claims based on the concept of **peak oil**, the world is not on the verge of running out of petroleum, heavy oil, or tar sand bitumen. However, in spite of the current volatility of petroleum, cheap petroleum may be a problem in the future as recent **price fluctuations** have indicated—the causes vary from petroleum being more difficult to obtain from underground formations, especially **tight formations**, to the petropolitics of the various oil-producing nations.

With the entry into the twenty-first century, petroleum refining technology is experiencing great innovation driven by the increasing supply of heavy oils with decreasing quality and the fast increases in the demand for clean and ultraclean **vehicle fuels** and petrochemical raw materials. As feedstocks to refineries change, there must be an accompanying change in the refinery technology. This means a movement from conventional means of refining heavy feedstocks using (the currently typical) coking technologies to more innovative processes (including hydrogen management) that will produce the **ultimate amounts** of liquid fuels from feedstocks and maintain emissions within **environmental compliance**.

The industry will move predictably on to (1) deep conversion of heavy feedstocks, (2) higher hydrocracking and hydrotreating capacity, and (3) more efficient processes.

Refining technology has evolved considerably over the last century in response to changing requirements such as (1) a demand for gasoline and diesel fuel as well as fuel oil, (2) petrochemicals as building blocks for clothing and consumer goods, and (3) more **environmentally friendly** processes and products. As a result of this response, the production facilities within the refining industry have become increasingly diverse — **process configuration** varies from plant to plant according to its size, complexity, and **product slate**. Moreover, the precise configuration of the refinery of the future is unknown, but it is certain that no two refineries will adapt in exactly the same way. There are small refineries—1,500–5,000 barrels per day (bpd)—and large refineries that process in excess of 250,000 bpd. Some are relatively simple and produce only fuels, while other refineries, such as those with integrated **petrochemical processing** capabilities, are much more complex. Many refineries are part of large integrated oil companies engaged in all aspects of the petroleum technology—from (1) exploration, (2) production, (3) transportation, (4) refining, and (5) marketing of petroleum products.

The refining industry can be regarded as unique insofar as very few industries have to deal with a feedstock-product chain beginning at a natural resource that has to be recovered from a **subterranean** formation and proceed through the application of a variety of processes all the way through to the **end use consumer**. Furthermore, it is **imperative** for refiners to raise their operations to new levels of performance. Merely extending current process performance will most likely fail to meet most future **performance goals**. To do this, it will be necessary to reshape refining technology to be more adaptive to changing feedstocks and product demand and to explore the means by which the technology and methodology of refinery operations can be translated not only into increased **profitability** but also into **survivability**.

The future of the petroleum refining industry will be primarily on processes for the production of improved quality products. In addition to **heavy ends deep conversion**, there will also be changes in the feedstock into a refinery. Biomass, liquids from coal, and liquids from **oil shale** will increase in importance. These feedstocks (1) will be sent to refineries or (2) processed at a remote location and then blended with refinery stocks are options for future development and the nature of the feedstocks. Above all, such feedstock must be compatible with refinery feedstocks and not cause **fouling** in any form.

The panacea (rather than a Pandora's Box) for a variety of feedstocks could well be the gasification refinery. This type of refinery approaches that of a petrochemical complex, capable of supplying the traditional refined products, but also meeting much more severe **specifications**, and **petrochemical intermediates** such as olefins, aromatics, hydrogen, and methanol. Furthermore, **integrated gasification combined cycle** (IGCC) can be used to raise power from feedstocks such as vacuum residua and **cracked residua** (in addition to the production of synthesis gas), and a major benefit of the integrated gasification combined cycle concept is that power can be produced with the lowest sulfur oxide (SOx) and nitrogen oxide (NOx) emissions of any liquid/solid feed power generation technology.

Anyway, the refining industry will survive — being one of the most **resilient** industries to **commence operations** during the past 150 years.

IX. Answer the following questions:

1. Why may cheap petroleum be a problem in the future?
2. What will the industry move predictably on to?
3. What are the changing requirements for refining technologies?
4. Is the precise configuration of the refinery of the future known?
5. Why can the refining industry be regarded as unique?

6. What is the gasification refinery?
7. Why will the refining industry survive?

X. Give a short summary of the text according to the basic rules and structure.

UNIT 4 NATURAL GAS CHEMISTRY AND TECHNOLOGY

Text 1
Processing of Natural Gas

1.	**natural gas processing**	переработка природного газа
2.	**hydrogen sulphide**	сероводород
3.	**odourless**	без запаха
4.	**natural gas liquids (NGLs)**	жидкости, полученные из природного газа
5.	**liquid petroleum gas (LPG)**	сжиженный нефтяной газ
6.	**dry gas**	сухой газ; отбензиненный газ
7.	**wet gas**	сырой газ; неотбензиненный газ
8.	**sour gas**	серосодержащий газ
9.	**foul smell**	неприятный запах
10.	**sweet gas**	обессеренный/очищенный газ
11.	**pipeline quality natural gas**	газ, соответствующий требованиям транспортирования по трубопроводу
12.	**impose restrictions on**	устанавливать ограничения для
13.	**purify**	очищать
14.	**waste products**	отходы производства
15.	**associated hydrocarbons**	попутные углеводороды
16.	**oil recovery**	коэффициент нефтеотдачи, объём добычи нефти
17.	**removal**	удаление
18.	**scrubbers**	сепаратор газа
19.	**wellhead**	устье скважины

I. Analyze the formation of the following words and translate them:

Unprocessed, colourless, odourless, make-up, by-product, large-particle.

II. Complete the sentences with the following adjectives and translate them:

COMPLEX	**HYDROCARBON**	**LIQUID**	**PETROCHEMICAL**
PURE	**VARIOUS**	**MAJOR**	**MINOR**

1. Unprocessed natural gas consists of the lighter … fractions.
2. Gas may contain … amounts of propane, butane and pentane.
3. … methane is colourless, odourless and lighter than air.
4. Where the natural gas is low in these … hydrocarbons it is known as a 'dry' gas.
5. Ethane is widely used as a … feedstock.
6. … transportation pipelines usually impose restrictions on the make-up of the natural gas.
7. The actual practice of processing natural gas to pipeline dry gas quality levels can be quite ….
8. Four main processes remove the … impurities.

III. Match the two halves of the prepositional phrases and translate them:

1. be low …	a) fact
2. be composed …	b) by
3. be characterised …	c) in
4. in …	d) to
5. be removed …	e) of
6. in contrast …	f) from

IV. Identify the Verbal (Participle I, II or the Gerund) and translate the sentences:

1. These natural gas liquids are sold separately and have a variety of different uses; ***including*** ***enhancing*** oil recovery in oil wells, ***providing*** raw materials for oil refineries or petrochemical plants, and as sources of energy.
2. This separation of natural gas from oil is most often done ***using*** equipment ***installed*** at or near the wellhead.
3. It consists of a simple ***closed*** tank, where the force of gravity serves to separate the heavier liquids and the lighter gases.

4. It is possible that it will separate on its own, simply due to ***decreased*** pressure; much like ***opening*** a can of soda pop allows the release of ***dissolved*** carbon dioxide.
5. This is often used for wells ***producing*** high pressure gas along with light crude oil or condensate.
6. In addition to ***separating*** oil and some condensate from the wet gas stream, it is necessary to remove most of the associated water.
7. This means a movement from conventional means of ***refining*** heavy feedstocks ***using*** ***coking*** technologies to more innovative processes.

V. Look at the title of the text and the vocabulary to predict what the text is about.

VI. Skim through the text (= read quickly to get the gist) to check your ideas.

VII. Scan through the text and find out how pipeline quality dry natural gas is produced.

VIII. Read and translate the following text.

Unprocessed natural gas is composed of the lighter hydrocarbon fractions, mainly methane (CH_4) with some ethane (C_2H_6). Depending on the source of the gas it may contain minor amounts of propane (C_3H_8), butane (C_4H_{10}) and pentane (C_5H_{12}). Other constituents may or may not be present, such as the longer chain hydrocarbons, nitrogen (N_2), carbon dioxide (CO_2) and **hydrogen sulphide** (H_2S). Pure methane is colourless, **odourless** and lighter than air. Impurities such as hydrogen sulphide can give natural gas an odour.

Ethane, propane, butane, and pentane are known as **natural gas liquids** (NGLs). Propane and propane/butane mixtures are both known as **liquid petroleum gas** (LPG). The propane/butane mixtures can vary up to around 50 per cent of each. Ethane is widely used as a petrochemical feedstock. Where the natural gas is low in these liquid hydrocarbons it is known as a **'dry' gas**, in contrast to what is known as **'wet' gas** if the gas contains quantities of both propane and butane. A **'sour' gas** contains more than one part per million hydrogen sulphide and is characterised by a **foul smell**. A **'sweet' gas** has a low hydrogen sulphide content.

Hydrocarbon components		Typical	Attributes and Uses
Methane	CH_4	70% to 98%	Commercial gas for residential, industrial and power generation use
Ethane	C_2H_6	1% to 10%	Colorless, odorless, feedstock for ethylene
Propane	C_3H_8	Trace to 5%	Burns hotter than methane, common liquid fuel; Liquid Petroleum Gas (LPG)
Butane	C_4H_{10}	Trace to 2%	Safe, volatile, used in pocket lighters; LPG
Pentane	C_5H_{12}	Trace	Commonly used solvent
Non-hydrocarbon components			
Water vapor	H_2O	Inert	Occasionally used for reinjection
Carbon dioxide	CO_2	Inert	Colorless, odorless, used for reinjection
Nitrogen	N_2	Inert	Colorless, odorless, used for reinjection
Helium	He	Inert	Colorless, odorless, light gas; specialty uses
Hydrogen sulfide	H_2S	--	Poisonous, lethal, foul odor; corrosive

Figure 5. Natural gas composition

Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas, to produce what is known as **pipeline quality dry natural gas**. Major transportation pipelines usually **impose restrictions on** the make-up of the natural gas that is allowed into the pipeline. That means that before the natural gas can be transported it must be **purified**. While the ethane, propane, butane, and pentanes must be removed from natural gas, this does not mean that they are all '**waste products'**. In fact, **associated hydrocarbons**, known as *natural gas liquids* can be very valuable by-products of natural gas processing. These NGLs are sold separately and have a variety of different uses; including enhancing **oil recovery** in oil wells, providing raw materials for oil refineries or petrochemical plants, and as sources of energy.

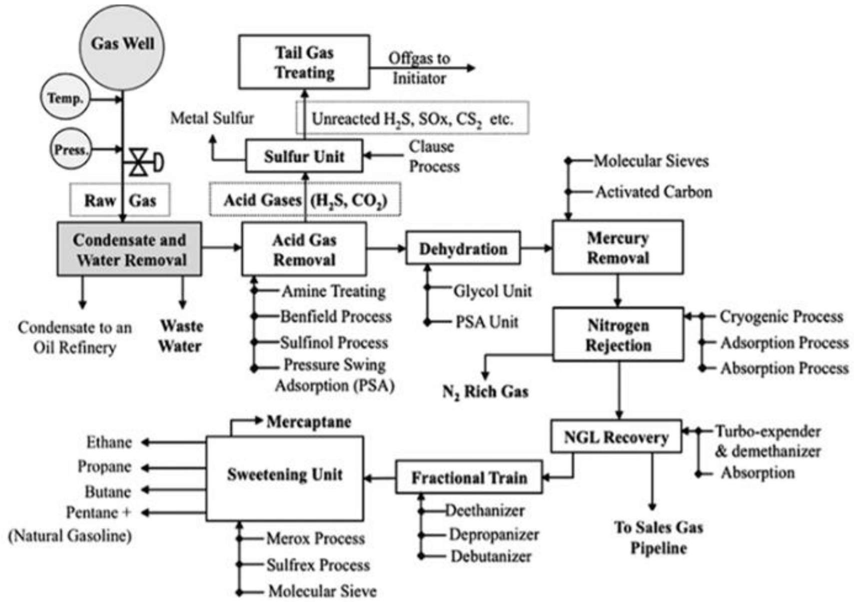

Figure 6. A generalized natural gas processing flow diagram

The actual practice of processing natural gas to pipeline dry gas quality levels can be quite complex, but usually involves four main processes to remove the various impurities:

- Oil and Condensate **Removal**
- Water Removal
- Separation of Natural Gas Liquids
- Sulfur and Carbon Dioxide Removal

In addition to the four processes above, heaters and **scrubbers** are installed, usually at or near the **wellhead**. The scrubbers serve primarily to remove sand and other large-particle impurities. The heaters ensure that the temperature of the gas does not drop too low.

IX. Answer the following questions:

1. What is unprocessed natural gas composed of?
2. What are natural gas liquids?
3. What is liquid petroleum gas?
4. What distinguishes 'dry', 'wet', 'sour' and 'sweet' gas?
5. Why must the natural gas be purified?

6. Why are pentanes, ethane, propane, and butane not ‘waste products’?
7. What are the four main processes to remove the various impurities?

X. Give a short summary of the text according to the basic rules and structure.

Text 2
Oil, Condensate and Water Removal

1. vary	варьироваться, изменяться
2. closed tank	герметически закрытый бак
3. force of gravity	сила тяжести
4. instances	случаи
5. low-temperature separator	низкотемпературный сепаратор
6. pressure differentials	разница давлений
7. gas stream	газовый поток
8. treatment	технологическая обработка
9. absorption	абсорбция
10. adsorption	адсорбция
11. dehydrating agent	влагопоглотитель
12. glycol dehydration	абсорбционная осушка природного газа гликолем
13. liquid desiccant	жидкий поглотитель
14. chemical affinity	химическое сходство
15. solution	раствор
16. diethylene glycol	диэтиленгликоль
17. triethylene glycol	триэтиленгликоль
18. particle	частица
19. vaporize	испарять
20. vent out	выветриваться
21. solid desiccant	твёрдый адсорбент
22. adsorption tower	адсорбционная колонна
23. activated alumina	активированный глинозём адсорбент,

	активированный оксид алюминия
24. desiccant bed	слой осушителя

I. Complete the table (when possible) with the words of the same root from the text and translate them:

VERB	**NOUN**	**ADJECTIVE**	**ADVERB**
remove			
	dehydration		
			relatively
		possible	
separate			
	requirement		
equip			
	heater		
adsorb			
	absorption		
			occasionally
boil			
		natural	
	solution		
		different	
	treatment		
	addition		
transport			
			usually
form			
	vapor		

II. Pay attention to the translation of <u>it/its/it is</u> and <u>that/these/those</u> in different functions:

1. In order to transport associated natural gas, ***<u>it</u>*** must be separated from the oil in which ***<u>it</u>*** is dissolved.
2. The natural gas is stripped of most of ***<u>its</u>*** water content.
3. When natural gas and oil are produced, ***<u>it</u>*** is possible that they will separate on their own.
4. By proceeding from the lightest hydrocarbons to the heaviest, ***<u>it</u>*** is possible to separate the different NGLs reasonably easily.
5. This boiling point differential makes ***<u>it</u>*** relatively easy to remove water from the glycol solution, allowing ***<u>it</u>*** to be reused in the dehydration process.

6. In certain instances, ***it*** is economic to simply leave the lighter NGLs in the natural gas stream.
7. Once NGLs have been removed from the natural gas stream, they must be broken down into their base components to be useful. ***That*** is, the mixed stream of different NGLs must be separated out.
8. Natural gas is dissolved in oil underground due to the pressure ***that*** the formation is under.
9. The removal of the water vapor ***that*** exists in solution in natural gas requires a more complex treatment.
10. ***This*** means ***that***, when in contact with a stream of natural gas that contains water, glycol will serve to 'steal' the water out of the gas stream.
11. ***These*** separators use pressure differentials to cool the wet natural gas.
12. The removal of natural gas uses techniques similar to ***those*** used to dehydrate natural gas.
13. Natural gas must be transported from ***those*** areas ***that*** produce natural gas, to ***those*** areas ***that*** require ***it***.
14. The mixture is heated to a temperature above the boiling point of the NGLs, but below ***that*** of the oil.

III. Look at the title of the text and the vocabulary to predict what the text is about.

IV. Skim through the text (= read quickly to get the gist) to check your ideas.

V. Scan through the text and find out the following abbreviations stand for: LTX, DEG, TEG.

VI. Read and translate the following text.

Oil and Condensate Removal. In order to process and transport associated natural gas, it must be separated from the oil in which it is dissolved. This separation of natural gas from oil is most often done using equipment installed at or near the wellhead. The actual process used to separate oil from natural gas, as well as the equipment that is used, can **vary** widely. Although dry pipeline quality natural gas is virtually identical across different geographic areas, raw natural gas from different regions may have different compositions and separation requirements. The most basic type of separator is known as a conventional separator. It consists of a simple **closed tank**, where the **force of gravity** serves to separate the heavier liquids like oil, and the lighter gases, like natural gas.

In many **instances**, natural gas is dissolved in oil underground primarily due to the pressure that the formation is under. When natural gas and oil are produced, it is possible that they will separate on their own, simply due to decreased pressure; much like opening a can of soda pop allows the release of dissolved carbon dioxide. In these cases, separation of oil and gas is relatively easy, and the two hydrocarbons are sent separate ways for further processing. In certain instances, however, specialized equipment is necessary to separate oil and natural gas. An example of this type of equipment is the **Low-Temperature Separator** (LTX). This is most often used for wells producing high pressure gas along with light crude oil or condensate. These separators use **pressure differentials** to cool the wet natural gas and separate the oil and condensate.

Water Removal. In addition to separating oil and some condensate from the wet **gas stream**, it is necessary to remove most of the associated water. Most of the liquid, free water associated with extracted natural gas is removed by simple separation methods at or near the wellhead. However, the removal of the water vapor that exists in solution in natural gas requires a more complex **treatment**. This treatment consists of 'dehydrating' the natural gas, which usually involves one of two processes: either **absorption**, or **adsorption**. Absorption occurs when the water vapor is taken out by a **dehydrating agent**. Adsorption occurs when the water vapor is condensed and collected on the surface.

Glycol Dehydration

An example of absorption dehydration is known as **Glycol Dehydration**. In this process, a **liquid desiccant** dehydrator serves to absorb water vapor from the gas stream. Glycol, the principal agent in this process, has a **chemical affinity** for water. This means that, when in contact with a stream of natural gas that contains water, glycol will serve to 'steal' the water out of the gas stream. Essentially, glycol dehydration involves using a glycol **solution**, usually either **diethylene glycol** (DEG) or **triethylene glycol** (TEG), which is brought into contact with the wet gas stream in what is called the 'contactor'. The glycol solution will absorb water from the wet gas. Once absorbed, the glycol **particles** become heavier and sink to the bottom of the contactor where they are removed. The natural gas, having been stripped of most of its water content, is then transported out of the dehydrator. The glycol solution, bearing all of the water stripped from the natural gas, is put through a specialized boiler designed to **vaporize** only the water out of the solution. While water has a boiling point of 212 degrees Fahrenheit, glycol does not boil until 400 degrees Fahrenheit. This boiling point differential makes it relatively easy to remove water from the glycol solution, allowing it to be reused in the dehydration process.

An innovation in this process has been the addition of **flash tank separator-condensers**. As well as absorbing water from the wet gas stream, the glycol solution occasionally carries with it small amounts of methane and other compounds found in the wet gas. In the past, this methane was simply **vented out** of the boiler. In addition to losing a portion of the natural gas that was extracted, this venting contributes to air pollution and the greenhouse effect. In order to decrease the amount of methane and other compounds that are lost, flash tank separator-condensers work to remove these compounds before the glycol solution reaches the boiler.

Solid-Desiccant Dehydration

Solid-desiccant dehydration is the primary form of dehydrating natural gas using adsorption, and usually consists of two or more **adsorption towers**, which are filled with a solid desiccant. Typical desiccants include **activated alumina** or a granular silica gel material. Wet natural gas is passed through these towers, from top to bottom. Passing through the entire **desiccant bed**, almost all of the water is adsorbed onto the desiccant material, leaving the dry gas to exit the bottom of the tower.

Solid-desiccant dehydrators are typically more effective than glycol dehydrators. These types of dehydration systems are best suited for large volumes of gas under very high pressure, and are thus usually located on a pipeline downstream of a compressor station. Two or more towers are required due to the fact that after a certain period of use, the desiccant in a particular tower becomes saturated with water. To 'regenerate' the desiccant, a high-temperature heater is used to heat gas to a very high temperature. Passing this heated gas through a saturated desiccant bed vaporizes the water in the desiccant tower, leaving it dry and allowing for further natural gas dehydration.

VII. Answer the following questions:

1. Where is separation of natural gas from oil most often done?
2. When is specialized equipment to separate oil and natural gas necessary?
3. How is water removed?
4. What is glycol dehydration?
5. How do flash tank separator-condensers work?
6. What is the primary form of dehydrating natural gas using adsorption?
7. What dehydrators are typically more effective?

VIII. Give a short summary of the text according to the basic rules and structure.

Text 3
Separation of Natural Gas Liquids. Sulfur and Carbon Dioxide Removal

1.	**base component**	основной компонент
2.	**cryogenic expander**	криогенный расширитель
3.	**account for**	составлять, насчитывать
4.	**lean absorption oil**	тощее абсорбционное масло
5.	**rich absorption oil**	жирное абсорбционное масло
6.	**lean oil stills**	перегонные кубы для тощей нефти
7.	**boiling point**	температура кипения
8.	**refrigerated oil absorption method**	метод абсорбции охлажденным маслом
9.	**propane recovery**	регенерация пропана
10.	**turbo expander**	турбодетандер
11.	**expansion turbine**	турбодетандер, турбина дросселирования
12.	**temperature drop**	понижение температуры
13.	**maintain**	поддерживать (в к.-л. состоянии)
14.	**effluent**	выходящий поток

15.	**fractionation**	разделение на фракции; фракционирование
16.	**boiling off**	выпаривание
17.	**deethanizer**	деэтанизатор, установка удаления этана
18.	**depropanizer**	депропанизатор, установка для отделения пропана
19.	**debutanizer**	дебутанизатор, установка удаления бутана
20.	**butane splitter/ deisobutanizer**	колонна для отгонки изобутана
21.	**lethal** ['li:θ(ə)l]	летальный, смертельно опасный
22.	**hydrogen sulfide**	сероводород
23.	**sweetening**	очистка газа от сернистых соединений
24.	**amine solution**	аминовый раствор
25.	**Girdler process**	процесс Гирдлера
26.	**monoethanolamine**	моноэтаноламин
27.	**diethanolamine**	диэтаноламин
28.	**iron sponge**	губчатое железо, фильтр для очистки высокосернистого газа
29.	**elemental sulfur**	элементарная сера
30.	**sulfur containing discharge**	серосодержащие выбросы
31.	**Claus process**	Клаус-процесс получения газовой серы
32.	**polluting and harmful substance**	загрязняющее и вредное вещество
33.	**incineration** [ɪn'sɪnə'reɪʃ(ə)n]	сжигание отходов производства
34.	**tail gas cleanup**	доочистка отходящих газов
35.	**natural gas value chain**	производственно-сбытовая цепочка в газовом секторе

I. Match the English words and phrases to their Russian equivalents:

1. be similar to	a) по сути, по большому счёту
2. as opposed to	b) так же как
3. in much the same manner	c) в отличие от
4. allow for	d) по порядку, поочерёдно
5. essentially	e) быть похожим на

6. as to	f) аналогично, почти таким же образом
7. one by one	g) дать возможность, сделать возможным
8. as well as	h) относительно, касательно

II. Pay attention to the translation of the Infinitive:

1. If the salt content exceeds this value, the crude ***to be treated*** should undergo a purification process.
2. The unit can operate either in two or three stages, depending on the quality of the crude ***to be handled***.
3. Thermal cracking process is intended for handling heavy charge stock with a view ***to obtain*** motor gasoline, tractor kerosene and boiler fuel oil.
4. The basic absorption process can be modified ***to improve*** its effectiveness.
5. An expansion turbine is used ***to*** rapidly ***expand*** the chilled gases, which causes the temperature ***to drop*** significantly.
6. Part of the hot oil returns to the primary tower ***to maintain*** there the required temperature.
7. It also permits ***to achieve*** high economy in operation.
8. The process is said ***to be replaced*** by catalytic cracking.
9. The reaction is considered ***to cause*** reduction in boiling point.
10. This kind of pumps has long been known ***to be applied*** in cracking units.

III. Look at the title of the text and the vocabulary to predict what the text is about.

IV. Skim through the text (= read quickly to get the gist) to check your ideas.

V. Scan through the text and find out details of the Girdler process/ the Claus process.

VI. Read and translate the following text.

Separation of Natural Gas Liquids. Natural gas coming directly from a well contains many natural gas liquids that are commonly removed. In most instances, NGLs have a higher value as separate products, and it is thus economical to remove them from the gas stream.

The removal of natural gas liquids usually takes place in a relatively centralized processing plant, and uses techniques similar to those used to dehydrate natural gas.

There are two basic steps to the treatment of natural gas liquids in the natural gas stream. First, the liquids must be extracted from the natural gas. Second, these natural gas liquids must be separated themselves, down to their **base components**.

NGL Extraction

There are two principle techniques for removing NGLs from the natural gas stream: the absorption method and the **cryogenic expander** process. According to the Gas Processors Association, these two processes **account for** around 90 percent of total natural gas liquids production.

The Absorption Method

The absorption method of NGL extraction is very similar to using absorption for dehydration. The main difference is that, in NGL absorption, absorbing oil is used as opposed to glycol. This absorbing oil has an 'affinity' for NGLs in much the same manner as glycol has an affinity for water. Before the oil has picked up any NGLs, it is termed **'lean' absorption oil**. As the natural gas is passed through an absorption tower, it is brought into contact with the absorption oil which soaks up a high proportion of the NGLs. The **'rich' absorption oil**, now containing NGLs, exits the absorption tower through the bottom. It is now a mixture of absorption oil, propane, butanes, pentanes, and other heavier hydrocarbons. The rich oil is fed into **lean oil stills**, where the mixture is heated to a temperature above the **boiling point** of the NGLs, but below that of the oil. This process allows for the recovery of around 75 percent of butanes, and 85 – 90 percent of pentanes and heavier molecules from the natural gas stream.

The basic absorption process above can be modified to improve its effectiveness, or to target the extraction of specific NGLs. In the **refrigerated oil absorption method**, where the lean oil is cooled through refrigeration, **propane recovery** can be upwards of 90 percent, and around 40 percent of ethane can be extracted from the natural gas stream. Extraction of the other, heavier NGLs can be close to 100 percent using this process.

The Cryogenic Expansion Process

Cryogenic processes are also used to extract NGLs from natural gas. While absorption methods can extract almost all of the heavier NGLs, the lighter hydrocarbons, such as ethane, are often more difficult to recover from the natural gas stream. In certain instances, it is economic to simply leave the lighter NGLs in the natural gas stream. However, if it is economic to extract ethane and other lighter hydrocarbons, cryogenic processes are required for high recovery rates. Essentially, cryogenic processes consist of dropping the temperature of the gas stream to around -120 degrees Fahrenheit.

There are a number of different ways of chilling the gas to these temperatures, but one of the most effective is known as the **turbo expander** process. In this process, external refrigerants are used to cool the natural gas stream. Then, an **expansion turbine** is used to rapidly expand the chilled gases, which causes the temperature to drop significantly. This rapid **temperature drop** condenses ethane and other hydrocarbons in the gas stream, while **maintaining** methane in the gaseous form. This process allows for the recovery of about 90 to 95 percent of the ethane originally in the gas stream. In addition, the expansion turbine is able to convert some of the energy released when the natural gas stream is expanded into recompressing the gaseous methane **effluent**, thus saving energy costs associated with extracting ethane.

The extraction of NGLs from the natural gas stream produces both cleaner, purer natural gas, as well as the valuable hydrocarbons that are the NGLs themselves.

Natural Gas Liquid ***Fractionation***

Once NGLs have been removed from the natural gas stream, they must be broken down into their base components to be useful. That is, the mixed stream of different NGLs must be separated out. The process used to accomplish this task is called fractionation. Fractionation works based on the different boiling points of the different hydrocarbons in the NGL stream. Essentially, fractionation occurs in stages consisting of the **boiling off** of hydrocarbons one by one. The name of a particular fractionator gives an idea as to its purpose, as it is conventionally named for the hydrocarbon that is boiled off. The entire fractionation process is broken down into steps, starting with the removal of the lighter NGLs from the stream. The particular fractionators are used in the following order:

- ***Deethanizer*** – this step separates the ethane from the NGL stream.
- ***Depropanizer*** – the next step separates the propane.
- ***Debutanizer*** – this step boils off the butanes, leaving the pentanes and heavier hydrocarbons in the NGL stream.
- ***Butane Splitter*** *or* ***Deisobutanizer*** – this step separates the iso**-** and normal butanes.

By proceeding from the lightest hydrocarbons to the heaviest, it is possible to separate the different NGLs reasonably easily.

Sulfur and Carbon Dioxide Removal. In addition to water, oil, and NGL removal, one of the most important parts of gas processing involves the removal of sulfur and carbon dioxide. Natural gas from some wells contains significant amounts of sulfur and carbon dioxide. This natural gas, because of the rotten smell provided by its sulfur content, is commonly called '*sour gas'*. Sour gas is undesirable because the sulfur compounds it contains can be extremely harmful, even **lethal**, to breathe. Sour gas can also be extremely corrosive. In addition, the sulfur that exists in the natural gas stream can be extracted and marketed on its own.

Sulfur exists in natural gas as hydrogen sulfide (H_2S), and the gas is usually considered sour if the hydrogen sulfide content exceeds 5.7 milligrams of H_2S per cubic meter of natural gas. The process for removing hydrogen sulfide from sour gas is commonly referred to as '***sweetening'*** the gas.

The primary process for sweetening sour natural gas is quite similar to the processes of glycol dehydration and NGL absorption. In this case, however, **amine solutions** are used to remove the hydrogen sulfide. This process is known simply as the '*amine process'*, or alternatively as the ***Girdler process***. The sour gas is run through a tower, which contains the amine solution. This solution has an affinity for sulfur, and absorbs it much like glycol absorbing water. There are two principle amine solutions used, **monoethanolamine** (MEA) and **diethanolamine** (DEA). Either of these compounds, in liquid form, will absorb sulfur compounds from natural gas as it passes through. The effluent gas is virtually free of sulfur compounds, and thus loses its sour gas status. Like the process for NGL extraction and glycol dehydration, the amine solution used can be regenerated (that is, the absorbed sulfur is removed), allowing it to be reused to treat more sour gas. Although most sour gas sweetening involves the amine absorption process, it is also possible to use solid desiccants like **iron sponges** to remove the sulfide and carbon dioxide.

Sulfur can be sold and used if reduced to its elemental form. Elemental sulfur is a bright yellow powder like material, and can often be seen in large piles near gas treatment plants. In order to recover **elemental sulfur** from the gas processing plant, the **sulfur containing discharge** from a gas sweetening process must be further treated. The process used to recover sulfur is known as the ***Claus process***, and involves using thermal and catalytic reactions to extract the elemental sulfur from the hydrogen sulfide solution. In all, the Claus process is usually able to recover 97 percent of the sulfur that has been removed from the natural gas stream. Since it is such a **polluting and harmful substance**, further filtering, **incineration**, and **'*tail gas'* cleanup** efforts ensure that well over 98 percent of the sulfur is recovered.

Gas processing is an instrumental piece of the **natural gas value chain**. It is instrumental in ensuring that the natural gas intended for use is as clean and pure as possible, making it the clean burning and environmentally sound energy choice. Once the natural gas has been fully processed, and is ready to be consumed, it must be transported from those areas that produce natural gas, to those areas that require it.

VII. Answer the following questions:

1. Is it economical to remove NGLs from the gas stream?
2. What are two principle techniques for removing NGLs from the natural gas stream?
3. How can the basic absorption process be modified?
4. What are cryogenic processes used for?
5. What is known as the turbo expander process?
6. How does fractionation work?
7. What order are fractionators used in?
8. Can the sulfur that exists in the natural gas stream be extracted and marketed on its own?
9. What process is used to remove the hydrogen sulfide?
10. What process is used to recover sulfur?

VIII. Give a short summary of the text according to the basic rules and structure.

REFERENCES

1. Energy_Carrier [Электронный ресурс]. URL: https://en.wikipedia.org/wiki/Energy_carrier (дата обращения 20.01.2022).
2. Fossil-Fuel [Электронный ресурс]. URL: https://www.britannica.com/science/fossil-fuel (дата обращения 20.01.2022).
3. Fossil-Fuels [Электронный ресурс]. URL: https://en.wikipedia.org/wiki/Energy_carrier (дата обращения 20.01.2022).
4. Introduction to Natural Gas [Электронный ресурс]. URL: https://www.energy-transition-institute.com/documents/17779499/17781903/Introduction+to+Natural+Gas_FactBook.pdf (дата обращения 30.01.2022).
5. Non-Renewable-Energy [Электронный ресурс]. URL: https://www.nationalgeographic.org/encyclopedia/non-renewable-energy/ (дата обращения 20.01.2022).
6. Handbook_of_Petroleum_Refining [Электронный ресурс]. URL:http://eprints.abuad.edu.ng/555/1/Handbook_of_Petroleum_Refining-1.pdf (дата обращения 30.01.2022).
7. Plant-Processing of-Natural-Gas [Электронный ресурс]. URL: https://petex.utexas.edu/images/book_previews/Plant-Processing-of-Natural-Gas_previewwtrmrk.pdf (дата обращения 30.01.2022).
8. Primary Energy [Электронный ресурс]. URL: https://energyeducation.ca/encyclopedia/Primary_energy (дата обращения 20.01.2022).
9. Schobert, H. (2013). Chemistry of Fossil Fuels and Biofuels (Cambridge Series in Chemical Engineering). Cambridge: Cambridge University Press. DOI:10.1017/CBO9780511844188
10. Speight, James. (2012). The chemistry and technology of coal, third edition. DOI: 10.1201/b12497

ОГЛАВЛЕНИЕ