**МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РК**

**КАЗАХСКИЙ НАЦИОНАЛЬНЫЙ УНИВЕРСИТЕТ ИМ. АЛЬ-ФАРАБИ**

**Методическая разработка:**

**English for specific purposes for masters of chemical specialties**

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**Introduction**

 The manual is designed for the master students of chemical faculties. The manual consists of 15 units. Each unit includes the theoretical material on grammar and lexis which can be frequently-met in scientific-technical texts. The exercises are accompanied by the practical tasks in the form of translation exercises, transformational exercises, gap-filling exercises. The first unit of the manual considers the rules of reading chemical formulas, equations, mathematical symbols and SI.

 One of the most peculiar features of the manual is that it includes the transformational exercises which are aimed at improving the writing skills of the master students. These exercises help the master students understand the mechanism of using the given grammatical construction in the scientific text. Also this type of exercises can be used for foreign students. These exercises gradually improve the quality of the scientific writing of the students. To enrich the students’ terminological vocabulary the manual includes the texts on the specialty accompanied by the detailed vocabulary. The manual explains the rules to make up word combinations with terminological units.

 The manual contains the texts on pyrotechnics, nanoscience, petrochemistry, oil and gas engineering, organic chemistry, inorganic chemistry. Selecting the texts for the manual the authors take into account the majors which are offered by chemical faculties at the master program. At the end of the manual there are grammatical tests on the grammatical phenomena which are considered in the manual and texts for additional reading.

**Unit 1**

**How to read chemical formulas, equations and symbols**

Vocabulary

an equation – уравнение

a formula – формула

a power – степень

a degree – градус

a sign – знак

The figure before the compoud is a number of molecules we should read this way: 2МnО2 [ʹtu: ʹmᴐlɪkju:lz əvʹemʹenʹou ʹtu:]

(OH)2 – [ou eitʃ tu taimz]

Fe (II) – iron Roman two

Н+ — hydrogen ion [ʹhaɪdrɪʤən ʹaɪən] or univalent positive hydrogen ion

[ʹju:nɪˏveɪlənt ʹpᴐzətɪv ʹhaɪdrɪʤən ʹaɪən]

Cu++ — divalent positive cuprum ion [ʹdaɪveɪlənt ʹpᴐzətɪv ʹkju:prəm ʹaɪən]

Al+++ — trivalent positive aluminium ion [ʹtri:ˏveɪlənt ʹpᴐzətɪv ˏæljuʹmɪnjəm

ʹaɪən]

Сl- — negative chlorine ion [ʹnegətɪv ʹklᴐ:ʹri:n ʹaɪən] or negative univalent

chlorine ion [ʹnegətɪv ʹju:nɪʹveɪlənt ʹklᴐ:ʹri:n ʹaɪən]

Ca3+ — calcium plus three

Ca3- — calcium three negative

Sign — *or* **:** means bond and we don’t read it:



Sign = *means* **: :** two bonds and we don’t read it either :



Sign + we read like: plus, react with, if we have the plus on the both sides of equation, we read the plus on the second side as and.

Sign = we read like: to give or to form

Sign → we read: to give, to produce, to yield

Sign ↔ we read as: forms или is formed from

In the chemical equation in English we read the names of the compouds with the help of letters, for instance:

4HC1 + O2 = 2C12 + 2H2O [ʹfᴐ: ʹmᴐlɪkju:lz əv ʹeɪtʃ ʹsi: ʹel ʹplᴧs ʹou ʹtu: ʹgɪv ʹtu:

ʹmᴐlɪkju:lz əv ʹsi: ʹel ʹtu: end ʹtu: ʹmᴐlɪkju:lz əv ʹeɪtʃ ʹtu: ʹou]

Zn + CuSO4 = Cu + ZaSO4 [ʹzed ʹen ʹplᴧs ʹsi: ʹju: ʹes ʹou ʹfᴐ: ʹgɪv ʹsi: ʹju: ʹplᴧs ʹzed

ʹen ʹes ʹou ʹfᴐ:]

PC13 + 2C1 → PC15 [ʹpi: ʹsi: ʹel ʹθri: ʹplᴧs ʹtu: ʹmᴐlɪkju:lz əv ʹsi: ʹel ʹgiv ʹpi: ʹsi:

ʹel ʹfaɪv]

Also we can read chemical compounds in the equations using their names, for example:

C + O → CO – carbon plus oxygen yields carbon oxide

Powers

х2 – x squared, x square

x3 – x cubed, x cube

5 3 – five to the third power, the third power of five, five cubed

5-4 – five to the minus fourth power, the minus fourth power of five

52 – five to the second power, the second power of five, five squared

$\sqrt{4=2 }$ The square root of four is two

The square root out of four is (equals) two

$\sqrt[3]{27=3}$ The cube root of twenty seven is three

$\sqrt[4]{16=2}$ The fourth root of sixteen is two

$\sqrt{a }$ The square root of *a*

$\sqrt[3]{a }$ The cube root of *a*

$\sqrt[5]{ a^{2}}$ The fifth root out of *a* square

$\sqrt[5]{ a^{7}}$ The fifth root out of *a* to the power seven, to the seventh power

$√$ square root (out) of [ʹskwɛə ʼru:t (aut) ev] корень квадратный из

$\sqrt[3]{}$ cube root (out) of [ʹkju :b ʹru:t (aut) əv] корень ку­бический из

$\sqrt[n]{}$ n-th root (out) of [ʹenθʹru:t(aut) əv] корень n-й степени

Mathematical sings

**+** plus [plᴧs] 1.плюс; 2. знак плюс; 3. положитель­ная величина; 4.

добавочный, дополнительный

**-** minus [ʹmaines] 1. минус; без; 2. знак минус; 3. от­рицательная

величина; отрицательный

$\pm $ plus or minus [ʹplᴧs ᴐ: ʹmaɪnǝs] плюс минус

$\mp $ minus or plus [ʹmaɪnes ᴐ: ʹplᴧs]

**=** 1. sign of equality [ʹsaɪ n ov i:ʹkwᴐlɪtɪ] знак равен­ства; 2. equals, (is) equal to [ʹ:kwəlz], [izʹi:kwel tu] равняется, равно

**≠** (is) not equal to [iz nᴐt ʹi:kwəl tu] неравно

**~** difference [ʹdɪfrəns] разность

≈ approximately equal [əʹprᴐksɪmɪtli ʹi:kwəl] приблизительно равно

approaches [əʹproutʃɪz] достигает значения similar to [ʹsɪmɪlə tu] подобный

**>** greater than [ʹgreɪtə æn] больше (чем)

**>** not greater than [not ʹgreɪtə æn] не больше (чем)

**<** less than [ʹIes æn] меньше (чем)

not less than [nᴐtʹles æn] не меньше (чем)

$\geq $ equal or greater than [ʹi:kwəl ᴐ: ʹgreɪtə æn] боль­ше (чем) или

равно

$\leq $ equal or less than [ʹi:kwəl ᴐ: ʹles æn] меньше (чем) или равно

m2 – square meter

m3 – cubic meter

s2 – second squared

kg/m3 – kilogram per cubic meter

cm – centimeter

l – liter

km – kilometer

T – tone

N – Newton

Pa – Pascal

Mol – mole

s – second

10o C – 10 degrees Centigrade (Celsius)

10 K – 10 Kelvins

−10o – 10 degrees below zero

+ 10o – 10 degrees above zero

−10 K – minus 10 Kelvins

10o F – 10 degrees Fahrenheit

**[ ]** brackets, square brackets [ʹbrækɪts, ʹskwɛə ʹbrækɪts] pl. квадратные

скобки

**( )** parentheses, round brackets [pəʹrenθɪsi:z, ʹraund ʹbrækɪts] pl.

круглые скобки

**{ }** braces [ʹbreɪsɪz] pl. фигурные скобки

$\frac{y}{x}$ y over x

 **Exercise 1** Read the following chemical equations

Cu + 2H2SO4  = CuSO4 + SO2 + 2H2O

H2O + SO3 = H2SO4

Be2 C + 4H2O = 2 Be (OH)2 + CH4

CaO + H2O = Ca (OH)2

Ca3N2 + 6H2O = 3 Ca (OH)2 + 2NH3

2NO + O2 = 2 NO2

2SO2 + O2 ↔ 2SO3

2KHSO4 = H2O + K2S2O7

(NH4)2S2O8 + 2Ag = Ag2SO4 + (NH4)2SO4

Na2S2O3 + 4Cl2+5H2O = 2H2SO4 + 2NaCl + 6HCl

SO2 + Cl2 = SO2Cl2

SO2Cl2 + 2H2O = 2H2SO4 + 2 HCl

SO2+KMn + KOH → K2SO4 + MnO2

S + KMnO4 + KOH → K2SO4 + MnO2

H2S + KMnO4 + KOH → K2SO4 + MnO2

3SO2 + 2 KMnO4 + KOH → 2 KSO4 + 2 MnO2

**Exercise 2** Read the following SI unites and chemical formulas

kg/m3, kg/m2, 10-5, cm3, m /s2, l/s2, mm3, l2, mm/g, g3, H2O, S(II), Cu (III), KSO2, HCl, H2S, CaO, SiO, 2H2S, MnSO3, MgO, Cr (OH)2, Cr (OH)6, Ca(HCO)2, MgCO3, C6H6, C2H2OH, ZnCl, FeO, Li2O2, H+, Ca-, Cl+++.

**Exercise 3** Read the following mathematical symbols

a-5, x3, y2, ( ), { }, [ ], 12o C, 13oF, 14 K, - 13oC, +13oC, $\sqrt[5]{ 6^{2}}$, b$\leq $c, d$\geq $m, c $\leq $d, c ≈ v, m + d = s, d – k = f, $√6$, $\sqrt[3]{8}$, $\sqrt[n]{10}$, 65, 7-3, 197, $\frac{d}{x}$

**Exercise 4** Correct the mistakes

g3 – gram cube

mm/g – millimeter with gram

2Zn + C →CO + Zn – zinc 2 plus carbon and takes carbon oxide and zinc

$\sqrt[5]{5}$ – the root five of five

11o C – eleven degree

11o F – eleven zero

f+ g = t – f and g gives t

14-10 – fourteen to the minus ten degree

Cu + O → CuO – copper and oxygen give copper oxygen

Ca (III) – calcium three

 4 **>**  3 – four bigger than three

 2 **<** 5– two smaller than five

 x2 – x two

 5 + 4 = 9 – five plus four loses nine

TiO2 – ti: ai sekqnd ou

Mn2O7 – em en sekqnd ou sevn

Cl- – chlorine minus

Ca+++ – calcium three pluses

 (OH)2 – ou eitʃ tou

s2 – square second

**Exercise 5** Match the first column with the second one

|  |  |
| --- | --- |
| g/s | eks to the minus fifth power  |
| ZnO + C →CO + Zn  | di is less that si  |
| Zn (IV) | Newton  |
| x-5 | Zinc oxide plus carbon and yields carbon oxide and zinc  |
| d **<** c | Vanadium oxide  |
| VO | Zinc Roman four  |
| N | gram per second  |

**Exercise 6** Write the following formulas and equations in words

Н+

Cu+

Cd+++

Al++

Ca (OH)2

BaCO3 + Na2SO4 →BaSO4 + Na2CO3

ZnS + 2HCl = ZnCl2 + H2S

d-6

g8

kg / l

7oF

8oC

P2O5 + C → P + CO

HNO3 + Cu → Cu (NO3)2 + NO + H2O

K2Cr2O7 + H2S + H2SO4 → Cr2(SO4)3+ S + K2SO4 + H2O.

**Exercise 7** Write the following expressions in formulas

Eks cubed

Eks squared

Eight is greater than seven

Eleven degrees Celsius

Four molecules of water plus carbon dioxide

Calcium oxide

Gramm per liter

The tenth power of seven

Cubic meter

Square centimeter

Negative calcium ion

The square root of seven

Magnesium permanganate reacts with water

Trivalent positive aluminum ion

 Y over a

 Sodium Chloride plus hydrogen

Ten minus seven is equal to three

Second squared

Ten plus seven is equal to seventeen.

**Additional Grammar**

**Grammar: So, such, too, enough**

**Too**
**Use:**
**Too** means there is a lot of something. It shows a **negative opinion**.
**It’s too hot =** Itis very hot and I don’t like it.

Form:
You can use too before an adjective.
It’s too cold. My trousers are too small.

You can also use it before an adverb,
You walk too fast. James speaks too quietly.

Before a noun, use **too much** (uncountable nouns) or **too** **many** (countable nouns).
**I ate too much food.**
**I ate too many sandwiches.**

You can also use too much after a verb.
I ate too much.
Paul drinks too much.

**Enough**
**Use:**
**Enough** means you have what you need.
*We have* ***enough*** *food for everyone* = everyone has some food.
*We* ***don’t*** *have* ***enough*** *chairs for everyone* = some people don’t have chairs.

**Form:**
Write **enough** before a noun.
*We have enough chairs.*

But write it after an adjective or verb.
Are you warm enough?  He’s qualified enough. She isn’t tall enough to be a model.

You don’t work hard enough. Are you sleeping enough?

Sentences with **enough** are sometimes followed by **to + verb infinitive.**
I’m not tall enough to reach the book.
I haven’t got enough money to buy that coat.

**So**
**Use:**
**So** means very.
*It’s* ***so*** *hot!*

**Form:**
**So** is generally used before an adjective or an adverb.
*He’s* ***so*** *funny! He plays the piano* ***so*** *well!*

However, in modern English, it is increasingly being used before nouns and verbs.
*That dress is* ***so*** *last year!* (= That dress is last year’s fashion)
*I’m* ***so*** *going to shout at him when I see him!* (so = really)

**So** can be used with a **that** clause, to show a **result** of the first clause.
*I was* ***so*** *hot* ***that*** *I couldn’t sleep.*
**Such**
**Use:**
**Such** also means very. **Such** isused before anadjective and noun.
*They are* ***such*** *nice children.*
**Form:**
**A / an,** if necessary, go **after** such, not before.
~~That’s a such pretty dress~~. => That’s **such** a pretty dress!

Like **So, Such** can be used with a **that** clause, to show a **result** of the first clause.
*It was* ***such*** *a nice day that we decided to go to the park.*

Common mistakes

1) Some students use **too** with a positive meaning. But you should use **so** or **very** here.
*~~It’s too hot! I love the summer!~~* => *It’s* ***so*** *hot! I love the summer!*

2) Some students write **enough** in the wrong place.
*~~Do we have sugar enough?~~* => *Do we have* ***enough*** *sugar?*

Practical test

1. Which sentence is incorrect?

a) This substance is too brittle.

b) Don’t add too much acid!

c) This substance too is dull.

2. Which sentence is correct ?

a) This equation is such a difficult.

b) Do we have acid enough?

c) This metal is such a good conductor of electricity.

3. Which word goes in space: This substance produced too …. smoke.

a) much

b) many

c) any

4. Which word goes in space: This acid is …harmful.

a) such

b) so

c) enough

5. Which sentence is incorrect ?

a) This substance produced smoke enough.

b) This substance doesn’t react well enough with sulhpuric acid.

c) This equation is too difficult for me.

6. Which word goes in space: Chemistry is …. an interesting science

a) an

b) such

c) so

7. Which sentence is incorrect ?

a) The density of metalloids is much low.

b) Metalloids don’t have enough electrons.

c) Metalloids conduct enough electricity.

**Unit 2**

**Grammar**

**Passive Voice Structures: under + noun**

 1. We don’t use Present / Future / Past Perfect Continuous in Passive Voice. Instead of it we use special structures: “under + verbal noun” (in this structure we can use only verbal nouns which end in “-ion”, for example: consideration, construction), “in + verbal noun” (use, training development) or Perfect Simple. For instance:

|  |  |
| --- | --- |
| Active Voice  | Passive Voice  |
|  We have been discussing this problem for three hours.  | Perfect Simple  | Under + verbal noun  |
| This problem has been discussed by us for three hours.  | This problem has been under discussion by us for three hours.  |

|  |  |
| --- | --- |
| Active Voice  | Passive Voice  |
|  We have been using this method for three years.  | Perfect Simple  | In + verbal noun |
| This method has been used by us for three years | This method has been in use by us for three years.  |

 2. The structures: “under + noun” can play the role of an adjective and can be translated as an adjective into Russian. For instance: The problem **under investigation** is of a great importance. – **Исследуемый** вопрос имеет важное значение. Here are some examples of these phrases which are often met in scientific texts:

under consideration , under examination - рассматриваемый

under review, under investigation - исследуемый

under study, under observation - наблюдаемый

under test - испытуемый

under way – осуществляемый

Impersonal Passive Constructions

Считается, что это вещество обладает высокой реакционной способностью. – This substance is considered to have a high reactivity.

**Present:** Предполагается, что это вещество реагирует при температуре 600 оС . - This substance is assumed to react at 600 o C.

**Past:** Предполагается, что это вещество реагировало при температуре 600 оС . - This substance is assumed to have reacted at 600 o C.

We use the structure: “To + have + V3 (Ved)” when we want to emphasize that the action took place in the past.

|  |  |
| --- | --- |
| Present  | Past  |
| Active Form  | Passive Form  | Active Form  | Passive form  |
| To do  | To be done  | To have done  | To have been done  |

Examples:

 Active Form

**Present:** Было доказано что эти вещества не реагирует друг с другом при высоких температурах. – These substances were proved not **to react** with each other at high temperatures.

**Past:** Установлено, что эти свойства изменились при повышении давления. – These properties were found out **to have changed** with (when) increasing pressure.

Passive Form

**Present:**  Считается, что этот метод **используется** при получении новых веществ. – This method is considered to **be used** when obtaining new substances.

**Past:**  Было показано, что эти вещества **были получены** при разных температурах. – These substances were shown to **have been obtained** at various temperatures.

 **Exercise 1** Remake the following sentences: It was found out that temperature changes during synthesis.- Temperature was found out to change during synthesis.

1. It is shown that the substances change their composition at a high pressure.
2. It was proved that the given substance influenced the overall yield.
3. It was established that this reaction runs at a low temperature.
4. It was concluded that these reactions were similar.
5. It was shown that the configuration didn’t change its shape.
6. It was shown that the isomerization product was not diketene but pyrazole.
7. It was proved that the yield decreased by 20 %.
8. It was shown that this substance reacted more rapidly than that one.
9. It is supposed that temperature changes drastically under such conditions.
10. It is supposed that isomers are in dynamic equilibrium with each other.
11. It was found that the time of inversion was 10-11 seconds.
12. It was calculated that the ionic character of these bonds is similar.
13. It is considered that high dipole moments are the proof of double bond nature of phosphoryl group.
14. It is considered that this process runs at a low pressure and temperature.
15. It was found out the solution contained impurities.
16. It was found that lactams with large rings are obtained by Wallach’s method.
17. It was shown that resins are based on the substances which contain phenolic groups.

**Exercise 2** Remake the following structures using Passive:We studied this reaction. – This reaction was studied by us.

1. We obtained lactams by Wallach’s method.
2. We dissolved sodium chloride in water solution.
3. We added this compound to the saline solution.
4. We found the new values of constants.
5. We usually carry out this experiment at a high pressure.
6. Chlorination decreased the yield by 20 %.
7. The presence of graphite influences the chlorination of mercury oxide.
8. We calculated the degree of ionization.
9. We demonstrated the procedure of obtaining sodium oxide.

**Exercise 3** Remake the following phrases using structures under +noun**:** the reaction which is being studied – the reaction under study

1. The method which is being considered
2. The procedure which is being studied
3. The process which is being observed
4. The phosphoryl group which is being examined
5. The problem which is being discussed
6. The medicine which is being tested
7. The method which is being used
8. The substance which is being investigated
9. The book which is being reviewed

Vocabulary

ionic bonding - ионная связь

сovalent bonding - ковалентная связь

sodium - натрий

to burn - гореть

compound – соединение

conducting solution - проводящий раствор

melting point - температура плавления

to dissolve - растворяться

valence shell - валентная оболочка

charged - заряженный

electrostatic attraction - электростатическое напряжение

to be composed of - состоять

attractive force - сила притяжения

oppositely charged ions - противоположно заряженные ионы

an ionic compound - ионное соединение

sodium chloride - хлорид натрия

chlorine - хлор

property - свойство

bond - связь

to result in - приводить к

double covalent bond - двойная ковалентная связь

hydrogen - водород

fluorine - фтор

carbon dioxide - диоксид углерода

carbon tetrafluoride - тетрафторид углерода

liquid - жидкость

room temperature - комнатная температура

half-filled - наполовину заполненный

filled - заполненный

**Translate the text and ask 10 questions on the content of the text**

**Text**

**Ionic Bonding and Covalent Bonding**

 When sodium is burned in a chlorine atmosphere, it produces the compound sodium chloride. This has a high melting point (800 ºC) and dissolves in water to to give a conducting solution. Sodium chloride is an ionic compound, and the crystalline solid has the structure shown on the right. Transfer of the lone 3s electron of a sodium atom to the half-filled 3p orbital of a chlorine atom generates a sodium cation (neon valence shell) and a chloride anion (argon valence shell). Electrostatic attraction results in these oppositely charged ions packing together in a lattice. The attractive forces holding the ions in place can be referred to as ionic bonds.

 The other three reactions shown above give products that are very different from sodium chloride. Water is a liquid at room temperature; carbon dioxide and carbon tetrafluoride are gases. None of these compounds is composed of ions. A different attractive interaction between atoms, called covalent bonding, is involved here. Covalent bonding occurs by a sharing of valence electrons, rather than an outright electron transfer. Similarities in physical properties (they are all gases) suggest that the diatomic elements H2, N2, O2, F2 & Cl2 also have covalent bonds.
Examples of covalent bonding shown below include hydrogen, fluorine, carbon dioxide and carbon tetrafluoride.

 These illustrations use a simple Bohr notation, with valence electrons designated by colored dots. Note that in the first case both hydrogen atoms achieve a helium-like pair of 1s-electrons by sharing. In the other examples carbon, oxygen and fluorine achieve neon-like valence octets by a similar sharing of electron pairs. Carbon dioxide is notable because it is a case in which two pairs of electrons (four in all) are shared by the same two atoms. This is an example of a double covalent bond.

**Unit 3**

**Unit 3**

**Attributive chains (AC)**

 Attributive chains are compound phrases which consist of two or more nouns connecting logically with each other where the preposition «of» is absent. E.g.:

the reaction of catalysis - catalysis reaction

the solution of benzene - benzene solution.

 As all compound phrases are formed in scientific literature with the help of genitive case (родительный падеж), most authors prefer to use attributive chains. To avoid the frequent repetition of the preposition «of» authors omit this preposition by transferring the word which must be after the preposition «of» at the beginning of a phrase. Let’s consider this process on the following example. At first we will translate all the words:

Горение жидкости ацетилена:

горение - combustion

жидкость - liquid

ацетилен – acetylene

Now let’s translate this phrase using the preposition «of»: горение жидкости ацетилена - the combustion of the liquid of acetylene. Here we can see two prepositions «of». Such kind of phrase is not good for English style. To get rid (избавиться) of the excessive (чрезмерный) use of the preposition «of» we should put the word «acetylene» at the beginning. The word «acetylene» will be the first. Then after the word «acetylene» we must put the word «liquid». It will be the second word. And finally the word «combustion» will be the last one in this phrase. As a result we have the following word combination: acetylene liquid combustion.

 Now let’s consider the translation of AC from English into Russian on the following example: magnesium oxide melting point.

At first of all we will translate all the words in this phrase:

magnesium - магний

oxide - оксид

melting point - температура плавления.

 When we translate from English into Russian we should start our translation from the last word. The first word will be **melting point** - температура плавления, the second word will be **oxide** - оксид and the last word will be **magnesium** - магний and finally we will have the following phrase: температура плавления оксида магния.

Structures: of + V+ing

Существует много разных методик определения состава этого вещества. - There are many procedures of the determination of the composition of this substance. Or There are many procedures of determining the composition of this substance.

Vocabulary

to proceed - проходить, протекать

toluene - толуол

well - скважина

commercial - производственный

hydrocarbon - углеводород

data - данные

reduction - восстановление

**Exercise 1** Translate the following sentences paying attention to the translation of the compound phrases.

1. We have obtained catalysis original data.
2. Silicon oxidation technique was successfully tested by researches last year.
3. Heavy hydrocarbon fuel has been added into this device.
4. Last time toluene reduction proceeded very slowly.
5. Commercial well drilling has opened a new era in petrochemistry.
6. Hydrogen oxide is the lightest compound in chemistry.
7. Benzene is a strong solvent.
8. Last year we developed a new combustion technique.
9. Toluene oxidation process has taken place at 40 K.
10. A new toluene production procedure was developed two years ago.
11. The detection method developed by Lovelock is widely-used by us.
12. Present - day theories attempt to explain this phenomenon.
13. Benzene structure analysis has been carried out by us.
14. The researchers couldn’t determine the soot yield.
15. Unfortunately, we haven’t obtained the analysis data yet.
16. We have used terbium oxide to obtain this substance.

**Exercise 2** Remake the following phrases.

For example: The procedure of the determination of a composition – the procedure of determining a composition.

1. The method of the determination of the content of silver
2. The procedure of the production of carbon (produce)
3. The procedure of the measurement of a size (measure)
4. The method of the establishment of sulphur composition (establish)
5. The reaction of the substitution of hydrocarbon (substitute)
6. The method of the creation of new carbon derivatives (create)
7. The procedure of the study of charcoal properties (study)
8. The method of the investigation of novel nanofilms. (investigate)

The method of the purification of water from impurities (purify)

The method of the refining of petroleum (refine)

**Exercise 3** Remake the following phrases.

For example: the content of sulphur – sulphur content

1. The size of a particle
2. The mass of a substance
3. The determination of a composition
4. The atom of hydrogen
5. The donation of an electron
6. The rate of a reaction
7. The measurement of a nanoparticle
8. The production of soot
9. The synthesis of sodium chloride
10. The definition of ionic bonding
11. The diagnostic of laser extinction

Vocabulary

electron configuration - электронная конфигурация

hydrogen - водород

carbon - углерод

oxygen - кислород

nitrogen - азот

major - главный

foundation - основа

consequently - следовательно

truncated - сокращенный

periodic table - периодическая таблица

lowest energy level - самый низкий энергетический уровень

to occupy - занимать

quantum level - квантовый уровень

appreciation - понимание

Aufbau principle - принцип построения

to proceed - переходить

halogen - галоген

shell - оболочка

to include - включать

to consist of - состоять

according to -согласно

commonly - обычно

encounter - встречаться

octet - группа из восьми частиц

member - член

exhibit - проявлять

bonding pattern - структура связи

unique – уникальный

to achieve - достигать

to rationalize - объяснять

row - ряд

to be unlike - быть непохожим

**Text**

**Translate the text and ask 10 questions on the content of the text**

**Electron configuration in the periodic table**

 Four elements, hydrogen, carbon, oxygen and nitrogen, are the major components of most organic compounds. Consequently, our understanding of organic chemistry must have, as a foundation, an appreciation of the electronic structure and properties of these elements. The truncated periodic table shown above provides the orbital electronic structure for the first eighteen elements (hydrogen through argon). According to the Aufbau principle, the electrons of an atom occupy quantum levels or orbitals starting from the lowest energy level, and proceeding to the highest, with each orbital holding a maximum of two paired electrons (opposite spins).

 Electron shell #1 has the lowest energy and its s-orbital is the first to be filled. Shell #2 has four higher energy orbitals, the 2s-orbital being lower in energy than the three 2p-orbitals. (x, y & z). As we progress from lithium (atomic number=3) to neon (atomic number=10) across the second row or period of the table, all these atoms start with a filled 1s-orbital, and the 2s-orbital is occupied with an electron pair before the 2p-orbitals are filled. In the third period of the table, the atoms all have a neon-like core of 10 electrons, and shell #3 is occupied progressively with eight electrons, starting with the 3s-orbital. The highest occupied electron shell is called the valence shell, and the electrons occupying this shell are called valence electrons.

 The chemical properties of the elements reflect their electron configurations. For example, helium, neon and argon are exceptionally stable and unreactive monoatomic gases. Helium is unique since its valence shell consists of a single s-orbital. The other members of group 8 have a characteristic valence shell electron octet (ns2 + npx2 + npy2 + npz2). This group of inert (or noble) gases also includes krypton (Kr: 4s2, 4p6), xenon (Xe: 5s2, 5p6) and radon (Rn: 6s2, 6p6). In the periodic table above these elements are colored beige. The halogens (F, Cl, Br etc.) are one electron short of a valence shell octet, and are among the most reactive of the elements (they are colored red in this periodic table). In their chemical reactions halogen atoms achieve a valence shell octet by capturing or borrowing the eighth electron from another atom or molecule. The alkali metals Li, Na, K etc. (colored violet above) are also exceptionally reactive, but for the opposite reason. These atoms have only one electron in the valence shell, and on losing this electron arrive at the lower shell valence octet. As a consequence of this electron loss, these elements are commonly encountered as cations (positively charged atoms). The elements in groups 2 through 7 all exhibit characteristic reactivities and bonding patterns that can in large part be rationalized by their electron configurations. It should be noted that hydrogen is unique. Its location in the periodic table should not suggest a kinship to the chemistry of the alkali metals, and its role in the structure and properties of organic compounds is unlike that of any other element.

 **Unit 4**

**When, While, + Ving or When, If + V3 (Ved)**

**When, While, + Ving**

**Выполняя свой эксперимент**, он получил несколько новых веществ. – **When (While) carrying out his experiment** he obtained a few new substances.

При разработке нового метода мы опираемся на старые. – **When developing a new method** we use the old ones.

When, If + V3 (Ved)

При обработке это вещество меняет свой цвет.-

When (If) this substances is treated it changes its color.

When (If) being treated this substances changes its color.

When (If) treated this substance changes its color.

**Exercise 1** Remake the following sentences. For example: When we studied the substance obtained we added it to the solution. – When studying the substance obtained we added it into the solution.

1. When cupric compounds change their color in the solution they turn red.
2. When the reaction runs it is studied.
3. When sulphur reacts with oxygen it forms a new compound.
4. When carbon reacts with nitrogen atoms it forms new compounds.
5. When silver dissolves in water it imparts the solution with a new color.
6. When the particle changes its size it usually shrinks.

**Exercise 2** Remake the following sentences. For example: When silver is added to the solution it dissolves. – When added into the solution silver dissolves.
1. When the substance is obtained it is studied.

2. When sulphur is added to the solution it dissolves.

3. When the diamond surface is treated it becomes smooth.

4. When hydrocarbons have triple bonds they are referred to alkenes.

5. When carbon is produced synthetically it is used in the production of lubricants.

6.If water is cooled it turns into ice.

7. If water is boiled it starts giving off steam.

**Exercise 3**  Translate the following sentences paying attention to the translation of participle constructions.

1. While taking part in the discussion he advanced his famous theory.
2. While being treated for several hours the compound turned dark red.
3. While being a boy he showed a great aptitude to chemistry.
4. When exposed to sunlight the peroxide is isomerized to ketone.
5. While being a young man of 16 Kekule synthesized his first compound.
6. When filtered through a crucible the solution was washed with water.
7. If diluted with water the solution will change its color.
8. If cooled the water turns into ice.
9. If exposed to moisture this substance will change its size.
10. If checked the results will be more precise.
11. If passed through the acidic solution the substance will turn red.
12. If obtained in the laboratory the substance will be more suitable for soap making.
13. If produced at a high pressure hydrocarbons have a large octane number.

Vocabulary

acetone peroxide- пероксид ацетона

explosive - взрывчатый, взрывчатое вещество

powder - порошок

distinctive - специфический

 bleach -like odor - запах, напоминающий запах отбеливателя

 susceptible - подверженный, неустойчивый

 heat - тепло

friction - трение

shock - удар

to alter - изменяться

impurity - примесь

sensitive - чувствительный

wet – влажный, смачивать

[cyclic](http://en.wikipedia.org/wiki/Alicyclic_compound%22%20%5Co%20%22Alicyclic%20compound) [trimer](http://en.wikipedia.org/wiki/Trimer_%28chemistry%29%22%20%5Co%20%22Trimer%20%28chemistry%29) – циклический триммер

to form - образовывать

angle strain - угловая деформация

under proper conditions - при соответствующих условиях

easily soluble - легко растворимый

acid - кислота

to detect - обнаруживать

nitrogenous explosive - селитряное (азотистое) взрывчатое вещество

to ignite - воспламеняться, зажигать, загороться

quantity - количество

chemical bond - химическая связь

to obtain - получать

due to - благодаря

significant – значительный

unconfined – неограниченный

decomposition – разложение, распад

to sublime - сублимироваться

designed - предназначенный

various - различный

to be in a good agreement with - совпадать с

solid - твердое тело, твердое состояние, твердая частица

rapid - быстрый

creation - образование

theoretical examination - теоретическое изучение

**Text**

**Translate the text and ask 10 questions on the content of the text**

**Acetone peroxide**

 Acetone peroxide (triacetone triperoxide, peroxyacetone, TATP, TCAP) is an [organic peroxide](http://en.wikipedia.org/wiki/Organic_peroxide%22%20%5Co%20%22Organic%20peroxide) and a [primary](http://en.wikipedia.org/wiki/Primary_explosive%22%20%5Co%20%22Primary%20explosive) [high explosive](http://en.wikipedia.org/wiki/High_explosive%22%20%5Co%20%22High%20explosive). It takes the form of a white crystalline powder with a distinctive [bleach](http://en.wikipedia.org/wiki/Sodium_hypochlorite%22%20%5Co%20%22Sodium%20hypochlorite)-like odor.

 It is susceptible to heat, friction and [shock](http://en.wikipedia.org/wiki/Shock_%28mechanics%29%22%20%5Co%20%22Shock%20%28mechanics%29). The instability is greatly altered by impurities, including its own [oligomers](http://en.wikipedia.org/wiki/Oligomer%22%20%5Co%20%22Oligomer). It is not easily soluble in water. It is more stable and less sensitive when it is wet.

 "Acetone peroxide" most commonly refers to the [cyclic](http://en.wikipedia.org/wiki/Alicyclic_compound%22%20%5Co%20%22Alicyclic%20compound) [trimer](http://en.wikipedia.org/wiki/Trimer_%28chemistry%29%22%20%5Co%20%22Trimer%20%28chemistry%29) TCAP (tri-cyclic acetone peroxide, or tri-cyclo, [C](http://en.wikipedia.org/wiki/Carbon%22%20%5Co%20%22Carbon)9[H](http://en.wikipedia.org/wiki/Hydrogen%22%20%5Co%20%22Hydrogen)18[O](http://en.wikipedia.org/wiki/Oxygen%22%20%5Co%20%22Oxygen)6) obtained by a reaction between [hydrogen peroxide](http://en.wikipedia.org/wiki/Hydrogen_peroxide%22%20%5Co%20%22Hydrogen%20peroxide) and [acetone](http://en.wikipedia.org/wiki/Acetone%22%20%5Co%20%22Acetone). The [dimer](http://en.wikipedia.org/wiki/Dimer_%28chemistry%29%22%20%5Co%20%22Dimer%20%28chemistry%29) (C6H12O4) and open [monomer](http://en.wikipedia.org/wiki/Monomer%22%20%5Co%20%22Monomer) are also formed, but under proper conditions the cyclic trimer is the primary product. A [tetrameric](http://en.wikipedia.org/wiki/Oligomer%22%20%5Co%20%22Oligomer) form was also described. In mildly acidic or neutral conditions, the reaction is much slower and produces more [monomeric](http://en.wikipedia.org/wiki/Monomer%22%20%5Co%20%22Monomer) [organic peroxide](http://en.wikipedia.org/wiki/Organic_peroxide%22%20%5Co%20%22Organic%20peroxide) than the reaction with a strong acid catalyst. Due to significant [angle strain](http://en.wikipedia.org/wiki/Angle_strain%22%20%5Co%20%22Angle%20strain) of the [chemical bonds](http://en.wikipedia.org/wiki/Covalent_bond%22%20%5Co%20%22Covalent%20bond) in the dimer and especially the monomer, they are even more unstable than the trimer.

 At room temperature, the trimeric form slowly [sublimes](http://en.wikipedia.org/wiki/Sublimation_%28phase_transition%29%22%20%5Co%20%22Sublimation%20%28phase%20transition%29). Acetone peroxide is notable as one of the few high explosives not containing [nitrogen](http://en.wikipedia.org/wiki/Nitrogen%22%20%5Co%20%22Nitrogen). This is one reason it has become popular with terrorists, as it can pass through scanners designed to detect nitrogenous explosives.

 TCAP generally burns when ignited, unconfined, in quantities less than about 4 grams. More than 4 grams will usually detonate when ignited; smaller quantities might detonate when even slightly confined. Completely dry TCAP is much more prone to detonation than the fresh product still wetted with water or acetone. Theoretical examination of the explosive [decomposition](http://en.wikipedia.org/wiki/Chemical_decomposition%22%20%5Co%20%22Chemical%20decomposition) of TCAP predicts "formation of [acetone](http://en.wikipedia.org/wiki/Acetone%22%20%5Co%20%22Acetone) and [ozone](http://en.wikipedia.org/wiki/Ozone%22%20%5Co%20%22Ozone) as the main decomposition products." This result is in good agreement with the results of 60 years of the study of controlled decompositions in various organic peroxides. It is the rapid creation of gas from a solid that creates the explosion. Very little heat is created by the explosive decomposition of TCAP. Acetone peroxide evaporates 6.5% in 24 hours at 14–18 °C. In open air at 25 °C it has a loss by sublimation of 68.6% in 14 days.

**Unit 5**

**Participle I**

Participle I has two forms: present and perfect. Present participle in the active voice is formed by adding ending -ing to the verb and translated by Russian participle of the active voice:

to buy - buying - покупать - покупающий.

 Present participle has also a passive form which is formed in the following way:

being + V3 (Ved) and is translated by Russian participle of the passive voice:

being bought - покупаемый или тот, который покупают.

 Perfect Participle has also both passive and active forms:

an active form: having bought - купив;

a passive form: having been bought - будучи купленный.

In the sentence it can play a few roles:

it can play the role of an attribute and be placed before or after a subject. In this case it is translated by a participle in an active voice or a subordinate clause.

E.g.: A number of animals living on the Earth eat plants. - Ряд животных, живущих (или которые живут) на земле, питаются растениями.

It can play the role of an adverb and be placed at the beginning of a sentence or at the end of a sentence. In this case it is translated by the Russian verbal participle. E.g.: Taking into account this news we decided to change our plans. - Принимая во внимание эту новость мы решили изменить наши планы.

It can play the role of a parenthetical word:

allowing for - принимая во внимание;

assuming that - полагая, что;

judging by - судя;

putting it mildly - мягко говоря;

roughly speaking - грубо говоря.

It can also play the role of a subject and is translated by a verbal noun, e.g.: Substituting carbon for this substance will reduce environmental pollution - Замена углерода на это вещество позволит снизить уровень загрязнения

Vocabulary

admixture - примесь

limited scope - ограниченная сфера применения

hydrochloric acid - соляная кислота

residue - остаток, осадок

powder- порошок

affinity - сродство

ketal - кетал

partake - участвовать

convention - условие

abstraction - отделение

nitrosation - нитрование

**Exercise 1** Translate the following sentences paying attention to Participle I.

1. This reaction involves the following temperature changes.
2. We have analyzed the following compounds.
3. The remaining admixtures were separated from the end product.
4. Judging by the results, the pressure has fallen.
5. These moving parts are electrically powered.
6. Considering the limited scope of the method it has been used by two researchers.
7. The yield was 12% of the dried wood, varying with the amount of hydrochloric acid.
8. This concerns the following problem.
9. Judging by the recent works one can say that some amount of ketal is present in diethyl.
10. The dialyzed solution was evaporated to dryness and the residue was dried at
11. 50 o C, giving nondeliquescent brown powder.
12. One should bear in mind that this information can be misleading.
13. Having determined all parameters we started our experiment.
14. The research being carried out by our Institute in this field is of a great importance.
15. We have obtained these values in the terms of the following formula.
16. Z is favoured by the following data.
17. What is the number of the scientists partaking in the conference ?
18. Having filtered the solution we defined its colour.
19. Having regarded to the summation convention we identified four different products.
20. If the attacking radical had a greater affinity for hydrogen, then the hydrogen-abstraction process would be favoured.
21. Having considered his article we decided to renew our research.
22. The process leading to nitrosation may consist o f a few steps.
23. Last year our researchers obtained remarkable results.

 **Exercise 2** Put the following verbs in Participle I: to follow, to plan, to buy, to give, to get, to receive, to write, to do, to make, to recognize, to invent, to see, to reproduce, to measure

Exercise 3

**a)**Remake the sentences using Perfect Participle. For example: When filtered the solution we heated it up. – Having filtered the solution we heated it.

1. When we obtained the substance we studied its composition.

2. When we carried the experiment we wrote the article.

3. When they measured the concentration they were able to obtain a new compound.

4. When we dissolved hydrochloric acid in water we obtained a new solution.

5. When we ignited acetone oxide we produced a flame of a red color.

6. After we calculated the density we found out the size.

7. When we calcined calcium oxide we added it to water.

8. When we dried the sample we investigated its properties.

9. When we obtained a new compound we tried to identify its composition.

b) Remake the following sentences using Perfect Participle in Passive. For example: 1. When the experiment was carried out it was included in the article. – Having been carried out the experiment was included in the article.

2. When boric acid was diluted it was poured into the flask.

3. When hydrochloric acid was added to the solution obtained it dissolved.

4. When cobalt was discovered it was actively used in the production of stained glass.

5. When magnesium is exhibited to sunlight it burns.

6. When the sample was dried at a room temperature it was placed in the furnace.

7. When gold is added to the acid it tarnishes.

8. When the parameters were measured they were recorded.

9. When flame was diluted by argon it turned yellow.

10. When water was cooled it turned into ice.

Vocabulary

carbon nanotube (CNT) - углеродная нанотрубка

ratio - соотношение

length-to-diameter ratio - соотношение длины к диаметру

golf club - клюшка для гольфа

baseball bat - бейсбольная бита

to find applications - применяться, находить применение

[thermal conductivity](http://en.wikipedia.org/wiki/Thermal_conductivity%22%20%5Co%20%22Thermal%20conductivity) - теплопроводность

owing to - благодаря

valuable - ценный

additive - добавка

to derive from - происходить из

discrete - отдельный

specific - определенный

angle - угол

[carbon fiber](http://en.wikipedia.org/wiki/Carbon_fiber%22%20%5Co%20%22Carbon%20fiber) - углеродное волокно

[single-walled nanotubes](http://en.wikipedia.org/wiki/Carbon_nanotube%22%20%5Cl%20%22Single-walled) (SWNTs) - однослойные (одностенные) нанотрубки

[multi-walled nanotubes](http://en.wikipedia.org/wiki/Carbon_nanotube%22%20%5Cl%20%22Multi-walled) (MWNTs) - многослойные (многостенные) нанотрубки

 semiconductor - полупроводник

to align - выпрямлять

rope – жгут

rolling angle- угол свертывания

sheet - пластина, лист

pi-stacking - pi-упаковка

to be held together -держаться вместе

strength - прочность

applied [quantum chemistry](http://en.wikipedia.org/wiki/Quantum_chemistry%22%20%5Co%20%22Quantum%20chemistry) - прикладная квантовая химия

[diamond](http://en.wikipedia.org/wiki/Diamond%22%20%5Co%20%22Diamond) - алмаз

stiff - плотный

respectively - соответственно

elastic module - модуль упругости

chemical bonding - химическая связь

density - плотность

high-carbon steel - высокоуглеродистая сталь

compared to - по сравнению с

**Text**

**Translate the text and ask 10 questions on the content of the text**

**Carbon nanotubes**

 Carbon nanotubes (CNTs) are [allotropes of carbon](http://en.wikipedia.org/wiki/Allotropes_of_carbon%22%20%5Co%20%22Allotropes%20of%20carbon) with a [cylindrical](http://en.wikipedia.org/wiki/Cylindrical%22%20%5Co%20%22Cylindrical) [nanostructure](http://en.wikipedia.org/wiki/Nanostructure%22%20%5Co%20%22Nanostructure). Nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1, significantly larger than for any other material. These cylindrical [carbon](http://en.wikipedia.org/wiki/Carbon%22%20%5Co%20%22Carbon) [molecules](http://en.wikipedia.org/wiki/Molecule%22%20%5Co%20%22Molecule) have unusual properties, which are valuable for [nanotechnology](http://en.wikipedia.org/wiki/Nanotechnology%22%20%5Co%20%22Nanotechnology), [electronics](http://en.wikipedia.org/wiki/Electronics%22%20%5Co%20%22Electronics), [optics](http://en.wikipedia.org/wiki/Optics%22%20%5Co%20%22Optics) and other fields of [materials science](http://en.wikipedia.org/wiki/Materials_science%22%20%5Co%20%22Materials%20science) and technology. In particular, owing to their extraordinary [thermal conductivity](http://en.wikipedia.org/wiki/Thermal_conductivity%22%20%5Co%20%22Thermal%20conductivity) and mechanical and [electrical](http://en.wikipedia.org/wiki/Electricity%22%20%5Co%20%22Electricity) properties, carbon nanotubes find applications as additives to various structural materials. For instance, nanotubes form a tiny portion of the material(s) in some (primarily [carbon fiber](http://en.wikipedia.org/wiki/Carbon_fiber%22%20%5Co%20%22Carbon%20fiber)) baseball bats, golf clubs, or car parts.

 Nanotubes are members of the [fullerene](http://en.wikipedia.org/wiki/Fullerene%22%20%5Co%20%22Fullerene) structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called [graphene](http://en.wikipedia.org/wiki/Graphene%22%20%5Co%20%22Graphene). These sheets are rolled at specific and discrete angles, and the combination of the rolling angle and radius decides the nanotube properties; for example, whether the individual nanotube shell is a [metal](http://en.wikipedia.org/wiki/Metal%22%20%5Co%20%22Metal) or [semiconductor](http://en.wikipedia.org/wiki/Semiconductor%22%20%5Co%20%22Semiconductor). Nanotubes are categorized as [single-walled nanotubes](http://en.wikipedia.org/wiki/Carbon_nanotube%22%20%5Cl%20%22Single-walled) (SWNTs) and [multi-walled nanotubes](http://en.wikipedia.org/wiki/Carbon_nanotube%22%20%5Cl%20%22Multi-walled) (MWNTs). Individual nanotubes naturally align themselves into "ropes" held together by [van der Waals forces](http://en.wikipedia.org/wiki/Van_der_Waals_force%22%20%5Co%20%22Van%20der%20Waals%20force), more specifically, pi-stacking.

 Applied [quantum chemistry](http://en.wikipedia.org/wiki/Quantum_chemistry%22%20%5Co%20%22Quantum%20chemistry), specifically, [orbital hybridization](http://en.wikipedia.org/wiki/Orbital_hybridization%22%20%5Co%20%22Orbital%20hybridization) best describes chemical bonding in nanotubes. The [chemical bonding](http://en.wikipedia.org/wiki/Chemical_bonding%22%20%5Co%20%22Chemical%20bonding) of nanotubes is composed entirely of *[sp](http://en.wikipedia.org/wiki/Sp2_bond%22%20%5Co%20%22Sp2%20bond)*[2](http://en.wikipedia.org/wiki/Sp2_bond%22%20%5Co%20%22Sp2%20bond) [bonds](http://en.wikipedia.org/wiki/Sp2_bond%22%20%5Co%20%22Sp2%20bond), similar to those of [graphite](http://en.wikipedia.org/wiki/Graphite%22%20%5Co%20%22Graphite). These bonds, which are stronger than the *[sp](http://en.wikipedia.org/wiki/Sp3_bond%22%20%5Co%20%22Sp3%20bond)*[3](http://en.wikipedia.org/wiki/Sp3_bond%22%20%5Co%20%22Sp3%20bond) [bonds](http://en.wikipedia.org/wiki/Sp3_bond%22%20%5Co%20%22Sp3%20bond) found in [alkanes](http://en.wikipedia.org/wiki/Alkane%22%20%5Co%20%22Alkane) and [diamond](http://en.wikipedia.org/wiki/Diamond%22%20%5Co%20%22Diamond), provide nanotubes with their unique strength.

 Carbon nanotubes are the strongest and stiffest materials yet discovered in terms of [tensile strength](http://en.wikipedia.org/wiki/Tensile_strength%22%20%5Co%20%22Tensile%20strength) and [elastic modulus](http://en.wikipedia.org/wiki/Elastic_modulus%22%20%5Co%20%22Elastic%20modulus) respectively. This strength results from the covalent sp2 bonds formed between the individual carbon atoms. In 2000, a multi-walled carbon nanotube was tested to have a tensile strength of 63 [gigapascals](http://en.wikipedia.org/wiki/Pascal_%28unit%29%22%20%5Co%20%22Pascal%20%28unit%29) (GPa). Further studies, such as one conducted in 2008, revealed that individual CNT shells have strengths of up to ~100 GPa, which is in agreement with quantum/atomistic models. Since carbon nanotubes have a low density for a solid of 1.3 to 1.4 g/cm3, its [specific strength](http://en.wikipedia.org/wiki/Specific_strength%22%20%5Co%20%22Specific%20strength) of up to 48,000 kN·m·kg−1 is the best of known materials, compared to high-carbon steel's 154 kN·m·kg−1.

**Unit 6**

**Participle II**

Participle II is formed by adding the ending -ed to the verb if it is a regular verb, in the case with irregular verbs we use the third form of the irregular verb.

 Participle II is translated by the Russian participle of passive voice with endings: -ен, -ем, -ат, ят: to play - played - играемый, сыгранный.

 It can also play a few roles in a sentence:

it can play the role of an attribute and be placed before or after a subject, sometimes there is a conjunction “as” before it and it can be translated by a subordinate clause with the word “в том виде как”, e.g.: The idea as stated by the scientists is not of any interest - Эта мысль, в том виде как она изложена учеными, не представляет никакого интереса.

 If Participle II stands before a subject it is translated by an attribute and put before a subject, e.g.: The instrument used is very reliable - Использованный прибор очень надежен. If Participle II is formed from the verb with a preposition, it will be translated by a subordinate clause with the word “который” and the preposition will be put at the beginning of a subordinate sentence, e.g.: Some theoretical considerations touched upon in the last chapter will be considered in the next work. - Некоторые теоретические соображения, о которых вскользь упоминалось в последней главе, будут освещены в следующей работе.

Participle II can play the role of an adverb and be placed at the beginning or at the end of a sentence. In this case it is translated by a subordinate clause with the conjunctions: “так как”, “когда”, “если”. E.g.: Written in pencil the article was difficult to read. - Так как статья была написана карандашом, ее трудно было читать. United we stand, divided we fall - Если мы вместе, мы выстоим, если мы врозь, мы падем.

Vocabulary

bromepoxide - бромэпоксид

velocity - скорость

as far as our knowledge goes - насколько нам известно

throw light - проливать свет

firmness - прочность

plate - пластина

equation - уравнение

to vary - изменяться

to calculate - рассчитывать

**Exercise 1** Translate the following sentences paying attention to Participle II.

1. The values obtained have a little relevance to this problem.
2. Increased inductive power affects the electron bonds.
3. It was shown that the velocity constant was unaffected by an increase in viscosity.
4. Confirmation of double bond types must be sought in the other part of spectrum.
5. The number of plates needed for chromatography is much higher than that required for distillation.
6. This suggests that these compounds obtained from the isomeric bromepoxides are not identical.
7. As far as our knowledge goes, the course of polymerization is almost the same as that observed with the pure monomer phase.
8. The data provided vary with the purpose of each particular investigation.
9. According to the viewpoint adopted the form of the equations 1 and 2 is an oversimplification.
10. This section concerned with the behaviour of optical isomers on melting should be studied closely.
11. We learnt that the results reported by these scientists were wrong.
12. We can also write that the heat energy absorbed in such a process to be as follows.
13. The results obtained are analogous to those reported by the previous researchers.
14. The difference between the values calculated was close to 2%.
15. The ore found in uranium is rarely-met naturally.
16. The products obtained are very pure.
17. The equipment delivered to us last week is of a good quality.
18. Both ketones distilled in vacuum weren’t obtained in this state.
19. The idea proposed by them will throw light on the firmness of the binding of groups.

**Exercise 2** Put the following verbs in Participle I: to obtain, to measure, to carry out, to deliver, to derive, to investigate, to study, to test, to calculate, to check, to verify, to describe.

**Exercise 3** Remake the following sentences using Participle II: The substance which was obtained is chlorine oxide. - The substance obtained is chlorine oxide.

1. Our report includes the parameters which were measured.
2. The results products which were obtained don’t contain impurities.
3. The results which were found out are accurate.
4. The concentration of hydrochloric acid which was changed during the experiment didn’t influence the solution color.
5. The material which was studied had many defects.
6. Sulfur oxide which was added to the solution was mixed with other compound.
7. This mixture which was obtained in the laboratory was used in the preparation of this compound.
8. The soot particles which were formed during combustion are of a large size.
9. The argon flame which was diluted by air was used in the experiment.

Vocabulary

diamond - алмаз

to arrange - располагать

conversion rate - скорость преобразования (трансформации)

negligible - незначительный

[covalent bonding](http://en.wikipedia.org/wiki/Covalent_bond%22%20%5Co%20%22Covalent%20bond) - ковалентная связь

[hardness](http://en.wikipedia.org/wiki/Scratch_hardness%22%20%5Co%20%22Scratch%20hardness) - твердость

cutting - резка

polishing tools - полировочные инструменты

rigid lattice - неподвижная решетка

to contaminate - загрязнять

impurity - примесь

face-centered - гранецентрический

boron - бор

radiation exposure - воздействие излучения

to occur - происходить

[chemical vapor deposition](http://en.wikipedia.org/wiki/Chemical_vapor_deposition%22%20%5Co%20%22Chemical%20vapor%20deposition) - химическое осаждение из паровой фазы

to determine - определять

to disperse - рассеивать

pressure - давление

amount – количество

 volcanic eruption - извержение вулкана

transparent - прозрачный

igneous rock - вулканогенная порода

silicon - кремний

growth - выращивание

technique - метод

to develop - разрабатывать

to resemble - быть похожим

to adapt - приспасабливать

**Text**

**Translate the text and ask 10 questions on the content of the text**

**Diamond**

 In [mineralogy](http://en.wikipedia.org/wiki/Mineralogy%22%20%5Co%20%22Mineralogy), diamond is a [metastable](http://en.wikipedia.org/wiki/Metastable%22%20%5Co%20%22Metastable) [allotrope of carbon](http://en.wikipedia.org/wiki/Allotropes_of_carbon%22%20%5Co%20%22Allotropes%20of%20carbon), where the carbon [atoms](http://en.wikipedia.org/wiki/Atoms%22%20%5Co%20%22Atoms) are arranged in a variation of the [face-centered cubic](http://en.wikipedia.org/wiki/Face-centered_cubic%22%20%5Co%20%22Face-centered%20cubic) crystal structure called a [diamond lattice](http://en.wikipedia.org/wiki/Diamond_lattice%22%20%5Co%20%22Diamond%20lattice). Diamond is less [stable](http://en.wikipedia.org/wiki/Chemical_stability%22%20%5Co%20%22Chemical%20stability) than [graphite](http://en.wikipedia.org/wiki/Graphite%22%20%5Co%20%22Graphite), but the conversion rate from diamond to graphite is negligible at [standard conditions](http://en.wikipedia.org/wiki/Standard_conditions_for_temperature_and_pressure%22%20%5Co%20%22Standard%20conditions%20for%20temperature%20and%20pressure). Diamond is renowned as a material with superlative physical qualities, most of which originate from the strong [covalent bonding](http://en.wikipedia.org/wiki/Covalent_bond%22%20%5Co%20%22Covalent%20bond) between its atoms. In particular, diamond has the highest [hardness](http://en.wikipedia.org/wiki/Scratch_hardness%22%20%5Co%20%22Scratch%20hardness) and [thermal conductivity](http://en.wikipedia.org/wiki/Thermal_conductivity%22%20%5Co%20%22Thermal%20conductivity). Those properties determine the major industrial application of diamond in cutting and polishing tools.

 Because of its extremely rigid lattice, it can be contaminated by very few types of impurities, such as [boron](http://en.wikipedia.org/wiki/Boron%22%20%5Co%20%22Boron) and [nitrogen](http://en.wikipedia.org/wiki/Nitrogen%22%20%5Co%20%22Nitrogen). Small amounts of defects or impurities (about one per million of lattice atoms) color diamond blue (boron), yellow (nitrogen), brown ([lattice defects](http://en.wikipedia.org/wiki/Lattice_defect%22%20%5Co%20%22Lattice%20defect)), green (radiation exposure), purple, pink, orange or red. Diamond also has relatively high [optical dispersion](http://en.wikipedia.org/wiki/Optical_dispersion%22%20%5Co%20%22Optical%20dispersion) (ability to disperse light of different colors). Most natural diamonds are formed at high temperature and pressure at depths of 140 to 190 kilometers (87 to 120 mi) in the Earth crust. Carbon-containing minerals provide the carbon source, and the growth occurs over periods from 1 billion to 3.3 billion years (25% to 75% of the [age of the Earth](http://en.wikipedia.org/wiki/Age_of_the_Earth%22%20%5Co%20%22Age%20of%20the%20Earth)). Diamonds are brought close to the Earth′s surface through deep [volcanic eruptions](http://en.wikipedia.org/wiki/Volcanic_eruptions%22%20%5Co%20%22Volcanic%20eruptions) by a [magma](http://en.wikipedia.org/wiki/Magma%22%20%5Co%20%22Magma), which cools into [igneous rocks](http://en.wikipedia.org/wiki/Igneous_rock%22%20%5Co%20%22Igneous%20rock).

 Diamonds can also be produced synthetically in a [high-temperature](http://en.wikipedia.org/wiki/HPHT_diamond%22%20%5Co%20%22HPHT%20diamond) process which approximately simulates the conditions in the Earth's crust. An alternative, and completely different growth technique is [chemical vapor deposition](http://en.wikipedia.org/wiki/Chemical_vapor_deposition%22%20%5Co%20%22Chemical%20vapor%20deposition) (CVD). Several non-diamond materials, which include [cubic zirconia](http://en.wikipedia.org/wiki/Cubic_zirconia%22%20%5Co%20%22Cubic%20zirconia) and [silicon carbide](http://en.wikipedia.org/wiki/Silicon_carbide%22%20%5Co%20%22Silicon%20carbide) and are often called [diamond simulants](http://en.wikipedia.org/wiki/Diamond_simulants%22%20%5Co%20%22Diamond%20simulants), resemble diamond in appearance and many properties. Special [gemological](http://en.wikipedia.org/wiki/Gemology%22%20%5Co%20%22Gemology) techniques have been developed to distinguish natural and [synthetic diamonds](http://en.wikipedia.org/wiki/Synthetic_diamond%22%20%5Co%20%22Synthetic%20diamond) and diamond simulants. A diamond is a [transparent](http://en.wikipedia.org/wiki/Transparency_%28optics%29%22%20%5Co%20%22Transparency%20%28optics%29) [crystal](http://en.wikipedia.org/wiki/Crystal%22%20%5Co%20%22Crystal) of [tetrahedrally](http://en.wikipedia.org/wiki/Tetrahedral-octahedral_honeycomb%22%20%5Co%20%22Tetrahedral-octahedral%20honeycomb) bonded carbon atoms in a covalent lattice ([sp](http://en.wikipedia.org/wiki/Orbital_hybridisation%22%20%5Co%20%22Orbital%20hybridisation)[3](http://en.wikipedia.org/wiki/Orbital_hybridisation%22%20%5Co%20%22Orbital%20hybridisation)) that crystallizes into the [diamond lattice](http://en.wikipedia.org/wiki/Diamond_cubic%22%20%5Co%20%22Diamond%20cubic) which is a variation of the [face centered cubic](http://en.wikipedia.org/wiki/Face_centered_cubic%22%20%5Co%20%22Face%20centered%20cubic) structure. Diamonds have been adapted for many uses because of the material's exceptional physical characteristics. Most notable are its extreme hardness and thermal conductivity (900–2,320 W·m−1·K−1).

**Unit 7**

**The Infinitive**

**The functions of the infinitive in a sentence**

The infinitive is an indefinite form of a verb. In a sentence it can play a few roles:

1.role of a subject: it is usually put at the beginning of a sentence and can be rendered by the indefinite form of a verb or a noun, e.g.: **To think** otherwise would be mistake. - **Думат**ь по другому было бы ошибкой.

2.Role of an object: infinitive is put after a predicate and is translated into Russian by an indefinite form of a verb , e.g.: We try to minimize the old disadvantages. - Мы стараемся свести к минимуму, ранее имевшиеся недостатки.

3.Role of an attribute: in this case infinitive is put after the word which it relates to and is translated by a subordinate clause with the word «который». E.g.: The curves to be presented in Part V were obtained using this method. - Кривые, которые были представлены в главе V, были получены при помощи этого метода.

4.Role of a parenthetical word: infinitive is usually put at the beginning of a sentence and has commas. It can be translated by a verbal participle or by an indefinite form of a verb. E.g. To sum up, we shall present the table. - Подводя итог, приведем таблицу.

Examples of verbs that play the role of a parenthetical word in a sentence:

To begin with - прежде всего

To make a long story short - короче говоря

To mention – если упомянуть

To put it briefly - короче говоря

To put it simply – проще говоря

Needless to say - нет надобности говорить

To say nothing of – не говоря уже

Suffice it to say – достаточно сказать

To be exact – точнее говоря

To sum up – подводить итог.

5.Role of an adverbial modifier: it can be put at the beginning or at the end of a sentence and be translated by an indefinite form of a verb with the conjunctions : “чтобы”, “для того чтобы”. There are two types of adverbial modifiers expressed in the form of infinitive:

a)infinitive of a purpose - this infinitive is put at the beginning of a sentence and has the following conjunctions: “so as to” - так чтобы, “in order to” - для того чтобы , “to” - чтобы. It is translated into Russian by an indefinite form of a verb with the

conjunctions: “с тем чтобы”, ”для того чтобы”. E.g. : To live long it is necessary to live slowly. - Чтобы жить долго, нужно жить не торопясь.

b)Infinitive of a consequence - this infinitive is put at the end of a sentence and it is preceded by the following words: “too” - слишком, “enough” -достаточно, “sufficiently” - достаточно, “sufficient” - достаточный. E.g.: Some people are too proud enough to admit that they don’t know it. - Некоторые люди достаточно горды, чтобы признать, что они не знают этого.

Infinitive of the verbs: “to give” - давать, “to yield” - вызывать, “to provide” - обеспечивать, “to form” - образовывать should be translated as a verbal participle, e.g.: Condensation proceeded as usual to give corresponding compounds - Конденсация протекала обычным путем, давая соответствующие соединения.

Vocabulary

to seek (sought, sought) - разрабатывать

elution - элюирование

rotation - вращение

spectrum (pl. spectra) - спектр

enhancement – усиление

**Exercise 1** Translate the following sentences paying attention to the infinitive.

1. It is the most difficult to oxidize this substance.
2. It is a simple matter to record a small wave.
3. The paper presents a new procedure to prepare these compounds.
4. It did not take them 2 hours to carry out this reaction.
5. Compound II can be hydrolyzed to yield free amine.
6. A more general theory must be sought to account for these interconversions.
7. Rotation spectra can be used to measure bond length.
8. The oxide preparation was closely controlled to minimize chlorides.
9. To minimize decomposition of the iodine –containing compound, he employed alkaline hydrolysis.
10. A given fluid is made to flow very slowly into the reaction vessel.
11. This phenomenon causes peaks emerging by elution from the column to be very asymmetric.
12. The enhancement in the intensity of this band is sufficient to enable conjugation to be recognized.

**Infinitive of a purpose**

 We measured the volume that we could determine the value of the mass. – We measured the volume to determine the value of the mass.

 **Exercise 2** Remake the following sentences using infinitive of a purpose

1. We diluted this solution with sodium chloride that we could change the solution color.
2. The potassium hydroxide usually dissolves in water that it can change its color.
3. This reaction occurs that it can produce vapors.
4. The electrostatic energy increases that it can increase potential energy of a molecule.
5. We used synthesis that we could accelerate calcination.
6. This process occurs fast that it can increase the concentration of the substances which are introduced.
7. The cupric compounds are oxidized at a high pressure that they can be used in the production of alloys.
8. We discovered this substance that we could racemize it subsequently.
9. We used this set-up that we could save our time and efforts.
10. We obtained a new solution that we could add it to our drug.
11. We developed this theory that we could explain the conversion taking place during heating.
12. We bought necessary equipment that we could carry out the experiments.
13. We hydrolyzed this compound that we could obtain a free amine.
14. Mercury was purified that it could be used in the second time.

**The infinitive as an attribute**

The results which were obtained will be useful for us. – The results to be obtained will be useful for us.

 **Exercise 3** Remake the following sentences using the infinitive as an attribute

1. The theory which was developed by us will be used in this experiment.
2. The oxides which were prepared were controlled thoroughly.
3. The rotating spectra which were used for measurements were presented in this paper.
4. The stability of anions which is conditioned by coupling becomes high.
5. This mixture which contains three substances is more effective than the previous one.
6. The gas which was used here released at a high pressure.
7. The wave which was fixed here can be recorded easily.
8. The method which was described in this article is used in the experiment.
9. The aluminum properties which were discussed in this chapter are very important.

Vocabulary

thermal cracking - термический крекинг

steam cracking - паровой крекинг

to observe - наблюдать

light - легкий

hydrogen-rich - водородсодержащий

[homolytic fission](http://en.wikipedia.org/wiki/Homolysis_%28chemistry%29%22%20%5Co%20%22Homolysis%20%28chemistry%29) - гомолитический распад

heavy - тяжелый

at the expense of - за счет

light fraction - легкая фракция

distillate - продукт перегонки

burner fuel - топочный мазут

petroleum coke - нефтяной кокс

feedstock - запас сырой нефти, сырье

saturated hydrocarbon - насыщенный углеводород

liquefied petroleum gas - сжиженный углеводородный газ

milder-temperature delayed coking - замедленное коксование при умеренной температуре

pyrolysis furnace - пиролизная печь

naphtha - лигроин, тяжелая бензиновая фракция

feed - исходное сырье, нефтяное сырье

unsaturated hydrocarbon - ненасыщенный углеводород

needle coke - игольчатый кокс

to dilute - разбавлять

yield - выход

to quench - гасить, тушить, закалывать

oxygen - кислород

transfer line [heat exchanger](http://en.wikipedia.org/wiki/Heat_exchanger%22%20%5Co%20%22Heat%20exchanger) - теплообменник трубопровода

quenching oil - закалочное масло

quenching header - коллектор для закалывания

steam cracker unit - установка для парового крекинга

**Text**

**Translate and put 10 questions on the content of the text**

**Thermal cracking and Steam cracking**

 Modern high-pressure thermal cracking operates at absolute pressures of about 7,000 kPa. An overall process of disproportionation can be observed, where "light", hydrogen-rich products are formed at the expense of heavier molecules. The actual reaction is known as [homolytic fission](http://en.wikipedia.org/wiki/Homolysis_%28chemistry%29%22%20%5Co%20%22Homolysis%20%28chemistry%29) and produces [alkenes](http://en.wikipedia.org/wiki/Alkene%22%20%5Co%20%22Alkene), which are the basis for the economically important production of [polymers](http://en.wikipedia.org/wiki/Polymer%22%20%5Co%20%22Polymer).

Thermal cracking is currently used to "upgrade" very heavy fractions or to produce light fractions or distillates, burner fuel and/or [petroleum coke](http://en.wikipedia.org/wiki/Petroleum_coke%22%20%5Co%20%22Petroleum%20coke). Two extremes of the thermal cracking in terms of product range are represented by the high-temperature process called "steam cracking" or [pyrolysis](http://en.wikipedia.org/wiki/Pyrolysis%22%20%5Co%20%22Pyrolysis) which produces valuable [ethylene](http://en.wikipedia.org/wiki/Ethylene%22%20%5Co%20%22Ethylene) and other feedstocks for the petrochemical industry, and the milder-temperature [delayed coking](http://en.wikipedia.org/wiki/Delayed_coking%22%20%5Co%20%22Delayed%20coking) which can produce, under the right conditions, valuable [needle coke](http://en.wikipedia.org/wiki/Needle_coke%22%20%5Co%20%22Needle%20coke), a highly crystalline petroleum coke used in the production of [electrodes](http://en.wikipedia.org/wiki/Electrode%22%20%5Co%20%22Electrode) for the [steel](http://en.wikipedia.org/wiki/Steel%22%20%5Co%20%22Steel) and [aluminum](http://en.wikipedia.org/wiki/Aluminium%22%20%5Co%20%22Aluminium) industries.

 Steam cracking is a [petrochemical](http://en.wikipedia.org/wiki/Petrochemical%22%20%5Co%20%22Petrochemical) process in which saturated [hydrocarbons](http://en.wikipedia.org/wiki/Hydrocarbon%22%20%5Co%20%22Hydrocarbon) are broken down into smaller, often unsaturated, hydrocarbons. It is the principal industrial method for producing the lighter [alkenes](http://en.wikipedia.org/wiki/Alkene%22%20%5Co%20%22Alkene) (or commonly [olefins](http://en.wikipedia.org/wiki/Olefin%22%20%5Co%20%22Olefin)), including [ethene](http://en.wikipedia.org/wiki/Ethene%22%20%5Co%20%22Ethene) (or [ethylene](http://en.wikipedia.org/wiki/Ethylene%22%20%5Co%20%22Ethylene)) and [propene](http://en.wikipedia.org/wiki/Propene%22%20%5Co%20%22Propene) (or [propylene](http://en.wikipedia.org/wiki/Propylene%22%20%5Co%20%22Propylene)). Steam cracker units are facilities in which a feedstock such as naphtha, liquefied petroleum gas (LPG), [ethane](http://en.wikipedia.org/wiki/Ethane%22%20%5Co%20%22Ethane), [propane](http://en.wikipedia.org/wiki/Propane%22%20%5Co%20%22Propane) or [butane](http://en.wikipedia.org/wiki/Butane%22%20%5Co%20%22Butane) is thermally cracked through the use of steam in a bank of pyrolysis furnaces to produce lighter hydrocarbons. The products obtained depend on the composition of the feed, the hydrocarbon-to-steam ratio, and on the cracking temperature and furnace residence time.

 In steam cracking, a gaseous or liquid hydrocarbon feed like [naphtha](http://en.wikipedia.org/wiki/Naphtha%22%20%5Co%20%22Naphtha), [LPG](http://en.wikipedia.org/wiki/Liquified_petroleum_gas%22%20%5Co%20%22Liquified%20petroleum%20gas) or [ethane](http://en.wikipedia.org/wiki/Ethane%22%20%5Co%20%22Ethane) is diluted with steam and briefly heated in a furnace without the presence of oxygen. Typically, the reaction temperature is very high, at around 850°C, but the reaction is only allowed to take place very briefly. In modern cracking furnaces, the residence time is reduced to milliseconds to improve yield, resulting in gas velocities faster than the [speed of sound](http://en.wikipedia.org/wiki/Speed_of_sound%22%20%5Co%20%22Speed%20of%20sound). After the cracking temperature has been reached, the gas is quickly quenched to stop the reaction in a transfer line [heat exchanger](http://en.wikipedia.org/wiki/Heat_exchanger%22%20%5Co%20%22Heat%20exchanger) or inside a quenching header using quench oil

**Unit 8**

**Lexis and scientific collocations**

**Scientific vocabulary**

***Evidence:***  доказательство; данные

X-ray evidence supports a head-tail structure of the polymer. – Рентгеновские данные подтверждают структуру полимера: «голова к хвосту».

***Experience***:  опыт, практика

The preparation of membranes is very much a matter of experience. – Изготовление мембран в значительной степени является вопросом практики.

However “на практике” is translated as “in practice”.

***To fail:*** means “negation”

X-ray pattern has failed to affirm this suggestion. – Рентгенограмма не подтвердила этого предположения.

***Desired:***  заданный, требуемый

To agree with: совпадать

***To document:***  освещать, описывать, излагать.

Collocations

**Method:**

**Adjectives:**  accurate – точный, effective – эффективный, efficient - эффективный, рациональный, целесообразный, продуктивный, reliable - надежный, tried- and – tested – проверенный на практике, tried - and – true - испытанный, верный, надежный, common – распространенный, conventional – общепринятый, традиционный, traditional, standard, simple, usual, well-established - надежный, new, innovative, novel.

**Verbs:**  to use, to employ, to utilize – использовать, to implement - внедрять, to follow, to apply - применять, to develop, to devise, to work out - разрабатывать, to invent – создавать, to involve - включать

This method involves many steps. - Этот метод включает много стадий.

This method employs computer software. - В этом методе используется программное обеспечение.

**Difference:**  “efficient” means that this thing works in a well-organized way without wasting time and energy. “Effective” means that this thing has a right effect, it solves a problem or gets a result.

**Exercise 1** Fill the gaps with the following words: fail (2 times), experience, desired, agree with, document (2 times), method, effective, employ.

1. We \_\_\_\_ this phenomenon in the last chapter.
2. Unfortunately we \_\_\_to obtain the necessary concentration.
3. This procedure was found out to be more \_\_\_\_than the previous one.
4. The results obtained by us don’t \_\_\_\_\_ theoretical data.
5. As \_\_\_\_ shows the accuracy of the experimental results depends on equipment.
6. This effect \_\_\_\_ in the literature.
7. We \_\_\_\_to obtain this substance at a high temperature.
8. To determine the composition of this mixture we used this \_\_\_\_.
9. In our previous experiment we \_\_\_\_this method.
10. We were able to obtain the \_\_\_\_concentration.

**Exercise 2** Make up 10 sentences with the word “method”

**Exercise 3** Give the definitions for the following words: effective, method, experience, reliable.

Vocabulary

fluid catalytic cracking - каталитический крекинг жидких топлив

oil refinery - нефтеперерабатывающий завод

cat cracker - установка каталитического крекинга

demand - спрос

gasoline - бензин

powdered catalyst - пылевидный катализатор

artificial rubber - синтетический каучук

 to suffer severe shortage - испытывать острый дефицит

supply - запас

fluidized bed - флюидный слой

alumina - глинозем

to suspend - взвешивать

flow – поток, проникать, проткекать

feed hydrocarbons - поступающие углеводороды

alumina-catalyzed cracking - крекинг на основе катализа глинозема

upward-sloped pipe - труба, направленная вверх

pumice stone - кусок пемзы

nozzle - сопло

silica-кремнезем

riser - восходящая труба

to spray - распылять

separation - разделение

to vaporize - испарять, выпаривать

high-molecular weight oil - нефть с большой молекулярной массой

break down - расщеплять

spent catalyst - отработанный катализатор

to burn off - выжигать

to restore - восстанавливать

to remove - удалять

to route - направлять

disengage - высвобождать, освобождать

**Text**

**Translate and put 10 questions on the content of the text**

**Fluid catalytic cracking (FCC)**

 Fluid catalytic cracking is a commonly used process, and a modern oil refinery will typically include a [cat cracker](http://en.wikipedia.org/wiki/Cat_cracker%22%20%5Co%20%22Cat%20cracker), particularly at refineries in the US, due to the high demand for [gasoline](http://en.wikipedia.org/wiki/Gasoline%22%20%5Co%20%22Gasoline). The process was first used around 1942 and employed a powdered [catalyst](http://en.wikipedia.org/wiki/Catalyst%22%20%5Co%20%22Catalyst). During the Second World War, in contrast to the Axis Forces which suffered severe shortages of gasoline and artificial rubber, the Allied Forces were supplied with plentiful supplies of the materials. Initial process implementations were based on low activity [alumina](http://en.wikipedia.org/wiki/Aluminium_oxide%22%20%5Co%20%22Aluminium%20oxide) catalyst and a reactor where the catalyst particles were suspended in a rising flow of feed hydrocarbons in a [fluidized bed](http://en.wikipedia.org/wiki/Fluidized_bed%22%20%5Co%20%22Fluidized%20bed).

 Alumina-catalyzed cracking systems are still in use in [high school](http://en.wikipedia.org/wiki/High_school%22%20%5Co%20%22High%20school) and [university](http://en.wikipedia.org/wiki/University%22%20%5Co%20%22University) [laboratories](http://en.wikipedia.org/wiki/Laboratory%22%20%5Co%20%22Laboratory) in experiments concerning alkanes and alkenes. The catalyst is usually obtained by crushing [pumice](http://en.wikipedia.org/wiki/Pumice%22%20%5Co%20%22Pumice) stones, which contain mainly [aluminum oxide](http://en.wikipedia.org/wiki/Aluminium_oxide%22%20%5Co%20%22Aluminium%20oxide) and [silica](http://en.wikipedia.org/wiki/Silicon_dioxide%22%20%5Co%20%22Silicon%20dioxide) into small, porous pieces. In the laboratory, aluminum oxide (or porous pot) must be heated.

 In newer designs, cracking takes place using a very active [zeolite](http://en.wikipedia.org/wiki/Zeolite%22%20%5Co%20%22Zeolite)-based catalyst in a short-contact time vertical or upward-sloped pipe called the "riser". Pre-heated feed is sprayed into the base of the riser via feed nozzles where it contacts extremely hot fluidized catalyst at 1,230 to 1,400 °F (666 to 800 °C). The hot catalyst vaporizes the feed and catalyzes the cracking reactions that break down the high-molecular weight oil into lighter components including LPG, gasoline, and diesel. The catalyst-hydrocarbon mixture flows upward through the riser for a few seconds, and then the mixture is separated via [cyclones](http://en.wikipedia.org/wiki/Cyclonic_separation%22%20%5Co%20%22Cyclonic%20separation). The catalyst-free hydrocarbons are routed to a main [fractionator](http://en.wikipedia.org/wiki/Fractionation%22%20%5Co%20%22Fractionation) for separation into fuel gas, LPG, gasoline, [naphtha](http://en.wikipedia.org/wiki/Naphtha%22%20%5Co%20%22Naphtha), light cycle oils used in diesel and jet fuel, and heavy fuel oil.

 During the trip up the riser, the cracking catalyst is "spent" by reactions which deposit coke on the catalyst and greatly reduce activity and selectivity. The "spent" catalyst is disengaged from the cracked hydrocarbon vapors and sent to a stripper where it is contacts with steam to remove hydrocarbons remaining in the catalyst pores. The "spent" catalyst then flows into a fluidized-bed regenerator where air (or in some cases air plus [oxygen](http://en.wikipedia.org/wiki/Oxygen%22%20%5Co%20%22Oxygen)) is used to burn off the coke to restore catalyst activity and also provide the necessary heat for the next reaction cycle, cracking being an [endothermic reaction](http://en.wikipedia.org/wiki/Endothermic_reaction%22%20%5Co%20%22Endothermic%20reaction). The "regenerated" catalyst then flows to the base of the riser, repeating the cycle.

**Unit 9**

**The cases of using the verbs: to produce, to evolve and to form**

**and its derivatives**

 We use “to produce” when it has the meaning of the verb “to give”. For instance: Эта реакция образует оксид ванадия. - This reaction gives or produces vanadium oxide.

 We use the word “production” in the case of obtaining a product, a result, a particle or a compound. For instance: High pressure causes the soot production in the flame. We also use this word in the case of obtaining a product in industrial and laboratory scale.

 We use “to form” when a process, physical conditions, a chemical reaction or other influence generates a new product. For instance: Этот оксид образуется при восстановлении металлического цинка. – This oxide is formed when reducing with metallic zinc.

 The word “formation” is used in the similar lexical situation as the verb “to form”. It is employed in the case of the generation of a new product or a phenomenon. For instance: Soot formation is caused by argon flame.

 We use “to evolve” in the meaning of “to release”, but we use it with heat and gas. For instance: Heat evolves at the end of this reaction.

 We use the word “evolution” when we talk about the release of heat and gas. For instance: This process resulted in gas evolution.

**Exercise 1**  Fill the gaps with verbs: to produce, to form, to evolve using them in a right grammatical form and with the words: evolution, formation, production.

1. This reaction occurs with \_\_\_\_\_of gas.
2. The \_\_\_\_\_of large benzene rings occurs at a high pressure.
3. Arsenic reacts with oxygen and \_\_\_\_a new compound.
4. A large amount of heat \_\_\_\_\_ when argon is added to the flame.
5. The \_\_\_\_\_of carbon fiber consists of many stages.
6. Our factory \_\_\_\_ large amounts of silicon dioxide using laser extinction.
7. Heat \_\_\_\_\_is a physical process which can be observed at a high temperature.
8. How do you \_\_\_\_\_boron oxide at the laboratory?
9. When is sulphuric acid \_\_\_\_\_?
10. When endothermic reactions occurs gas \_\_\_\_\_.
11. This substance is \_\_\_\_in the process of dissolving.
12. This salt is \_\_\_\_\_when magnesium reacts with this substance.
13. Black vanadium oxide is \_\_\_\_in the process of V2O5 reduction.

**Exercise 2** Make up 10 sentences with each of the following verbs: to give, to evolve and to produce.

**Exercise 3** Give the definitions for the following words: production, oxide, acid, evolution, formation.

Vocabulary

benzene - бензол

 to join - соединять

natural constituent - природный компонент

crude oil - сырая нефть

petrochemical - нефтехимический продукт

cyclic hydrocarbon - циклический углеводород

highly [flammable](http://en.wikipedia.org/wiki/Flammable%22%20%5Co%20%22Flammable) liquid - легковоспламеняющаяся жидкость

precursor - продукт предшествующий стадии реакции, прекурсор

[cumene](http://en.wikipedia.org/wiki/Cumene%22%20%5Co%20%22Cumene) - кумол, кумен

annulene - аннулен

heavy chemicals - тяжелые химические вещества, продукты основной химической промышленности

[octane number](http://en.wikipedia.org/wiki/Octane_number%22%20%5Co%20%22Octane%20number) - октановое число

styrene - стирол

to consume - использовать, потреблять

to contain - содержать

aromatic hydrocarbon - ароматический углеводород

manufacture - производство

cyclohexane - циклогексан

toluene - толуол

liquid range - жидкостный диапазон

**Text**

**Translate and put 10 questions on the content of the text**

**Benzene**

 Benzene is an [organic](http://en.wikipedia.org/wiki/Organic_compound%22%20%5Co%20%22Organic%20compound) [chemical compound](http://en.wikipedia.org/wiki/Chemical_compound%22%20%5Co%20%22Chemical%20compound) with the molecular formula [C](http://en.wikipedia.org/wiki/Carbon%22%20%5Co%20%22Carbon)6[H](http://en.wikipedia.org/wiki/Hydrogen%22%20%5Co%20%22Hydrogen)6. Its molecule is composed of 6 carbon atoms joined in a ring, with 1 hydrogen atom attached to each carbon atom. Because its molecules contain only carbon and hydrogen atoms, benzene is classed as a [hydrocarbon](http://en.wikipedia.org/wiki/Hydrocarbon%22%20%5Co%20%22Hydrocarbon).

Benzene is a natural constituent of [crude oil](http://en.wikipedia.org/wiki/Petroleum%22%20%5Co%20%22Petroleum), and is one of the most elementary [petrochemicals](http://en.wikipedia.org/wiki/Petrochemical%22%20%5Co%20%22Petrochemical). Benzene is an [aromatic hydrocarbon](http://en.wikipedia.org/wiki/Aromatic_hydrocarbon%22%20%5Co%20%22Aromatic%20hydrocarbon) and the second [*n*]-[annulene](http://en.wikipedia.org/wiki/Annulene%22%20%5Co%20%22Annulene) ([6]-annulene), a cyclic hydrocarbon with a continuous [pi bond](http://en.wikipedia.org/wiki/Pi_bond%22%20%5Co%20%22Pi%20bond). It is sometimes abbreviated [Ph](http://en.wikipedia.org/wiki/Phenyl%22%20%5Co%20%22Phenyl)–H. Benzene is a [colorless](http://en.wikipedia.org/wiki/Color%22%20%5Co%20%22Color) and highly [flammable](http://en.wikipedia.org/wiki/Flammable%22%20%5Co%20%22Flammable) liquid with a sweet smell. It is mainly used as a precursor to heavy chemicals, such as [ethylbenzene](http://en.wikipedia.org/wiki/Ethylbenzene%22%20%5Co%20%22Ethylbenzene) and [cumene](http://en.wikipedia.org/wiki/Cumene%22%20%5Co%20%22Cumene), which are produced on a billion kilogram scale. Because it has a high [octane number](http://en.wikipedia.org/wiki/Octane_number%22%20%5Co%20%22Octane%20number), it is an important component of [gasoline](http://en.wikipedia.org/wiki/Gasoline%22%20%5Co%20%22Gasoline), composing a few percent of its mass. Most non-industrial applications have been limited by benzene's [carcinogenicity](http://en.wikipedia.org/wiki/Carcinogen%22%20%5Co%20%22Carcinogen).

 **Benzene is used mainly as an intermediate** to make other chemicals. About 80% of benzene is consumed in the production of three chemicals, [ethylbenzene](http://en.wikipedia.org/wiki/Ethylbenzene%22%20%5Co%20%22Ethylbenzene), [cumene](http://en.wikipedia.org/wiki/Cumene%22%20%5Co%20%22Cumene), and [cyclohexane](http://en.wikipedia.org/wiki/Cyclohexane%22%20%5Co%20%22Cyclohexane). Its most widely produced derivative is ethylbenzene, precursor to [styrene](http://en.wikipedia.org/wiki/Styrene%22%20%5Co%20%22Styrene), which is used to make polymers and plastics. [Cyclohexane](http://en.wikipedia.org/wiki/Cyclohexane%22%20%5Co%20%22Cyclohexane) is used in the manufacture of Nylon. **Smaller amounts of benzene are used to make some types of [rubbers](http://en.wikipedia.org/wiki/Rubber%22%20%5Co%20%22Rubber),** [lubricants](http://en.wikipedia.org/wiki/Lubricant%22%20%5Co%20%22Lubricant), [dyes](http://en.wikipedia.org/wiki/Dye%22%20%5Co%20%22Dye), [detergents](http://en.wikipedia.org/wiki/Detergent%22%20%5Co%20%22Detergent), [drugs](http://en.wikipedia.org/wiki/Drug%22%20%5Co%20%22Drug), [explosives](http://en.wikipedia.org/wiki/Explosive%22%20%5Co%20%22Explosive), and [pesticides](http://en.wikipedia.org/wiki/Pesticide%22%20%5Co%20%22Pesticide).

In both the US and Europe, 50% of benzene is used in the production of [ethylbenzene](http://en.wikipedia.org/wiki/Ethylbenzene%22%20%5Co%20%22Ethylbenzene)/styrene, 20% is used in the production of [cumene](http://en.wikipedia.org/wiki/Cumene%22%20%5Co%20%22Cumene), and about 15% of benzene is used in the production of [cyclohexane](http://en.wikipedia.org/wiki/Cyclohexane%22%20%5Co%20%22Cyclohexane) (eventually to [nylon](http://en.wikipedia.org/wiki/Nylon%22%20%5Co%20%22Nylon)).

 Currently, the production of and demand for benzene in the Middle East register the greatest increases worldwide.

 In laboratory research, [toluene](http://en.wikipedia.org/wiki/Toluene%22%20%5Co%20%22Toluene) is now often used as a substitute for benzene. The solvent-properties of the two are similar, but toluene is less toxic and has a wider liquid range.

**Unit 10**

**Comparison constructions:**

**as + adjective + as; multiplier + as + adjective + as**

 Этот метод такой же эффективный, как и другой. – This method is **as effective as** the other one.

 Было доказано, что пик этого вещества стал в 7.5. раз выше, чем раньше. – This peak has been proven to have become **7.5. as high as** before.

 Эта процедура длилась до 80 часов. – This procedure continued for **as long as 80** hours.

Four times as long as – в четыре раза длиннее.

Ten times as fast as – в десять раз быстрее.

Half the size – в два раза меньше по размеру

Half the weight – в два раза меньше по весу.

**Exercise 1** Remake the sentences using the construction: as +adjective +as. For example: Hydrochloric acid is water soluble. Hydrogen sulphide is water soluble too. Hydrocholoric acid is as soluble as hydrogen sulphide.

1. Sulphuric acid is colorless. Oxygen is colorless too.
2. Pyrolysis is an effective method. Synthesis is an effective method too.
3. Benzene is a volatile substance. Hydrogen is a volatile substance too.
4. The substitution reaction is rapid. The addition reaction is rapid too.
5. Cobalt is blue. Cobalt oxide is blue too.
6. Carbon is light. Oxygen is light too.
7. Sulphur is yellow. Sulphuric acid is yellow too.
8. Calorimetry is a precise method. Calibration is a precise method too.
9. Styrene is a wide-used substance in industry. Carbon black is a wide -used substance in industry too.
10. Oil is readily-soluble. Boric acid is readily-soluble too.
11. Bismuth oxide is hard-soluble. Lead oxide is hard-soluble too.
12. Acetylene is high-explosive. Nitrogen oxide is high -explosive too.

**Exercise 2**  Correct the mistakes in the following sentences paying attention to the constructions: multiplier + as + adjective + as

1. This boiling took place 80 hours long.
2. This mixture produces residue two times more than the mixture used by us before.
3. Calcination lasted 60 hours long.
4. This substance decomposes 10 times faster than that one.
5. The substitution reaction occurs 10 times faster when peroxide is present in the reaction medium.
6. This method is 3 times more effective than the previous one.
7. These equations can be derived two times faster using these data.
8. The mercury -measurement method is three times effective than the one being described in the last chapter.
9. X substance is racemized three times faster than the substance obtained last time.

**Exercise 3**  Give the definition for the following terms: an acid, an oxide, oxygen, a reaction medium.

Vocabulary

alongside - кроме

thick layer - толстый слой

strong - прочный

light - легкий

 [hexagonal pattern](http://en.wikipedia.org/wiki/Hexagonal_tiling%22%20%5Co%20%22Hexagonal%20tiling) - гексагональная решетка

charcoal – древесный уголь

inteplanar spacing – межплоскостное пространство

atomic scale - в атомном масштабе

chicken wire - мелкая проволочная сетка

size - размер

single-layered - однослойный

carbon foil - углеродная фольга

**Text**

**Translate and put 10 questions on the content of the text**

**Graphene**

 Graphene is one of the crystalline forms of [carbon](http://en.wikipedia.org/wiki/Carbon%22%20%5Co%20%22Carbon), alongside [diamond](http://en.wikipedia.org/wiki/Diamond%22%20%5Co%20%22Diamond), [graphite](http://en.wikipedia.org/wiki/Graphite%22%20%5Co%20%22Graphite), [carbon nanotubes](http://en.wikipedia.org/wiki/Carbon_nanotubes%22%20%5Co%20%22Carbon%20nanotubes) and [fullerenes](http://en.wikipedia.org/wiki/Fullerenes%22%20%5Co%20%22Fullerenes). In this material, carbon atoms are arranged in a [regular hexagonal pattern](http://en.wikipedia.org/wiki/Hexagonal_tiling%22%20%5Co%20%22Hexagonal%20tiling). Graphene can be described as a one-atom thick layer of the layered mineral [graphite](http://en.wikipedia.org/wiki/Graphite%22%20%5Co%20%22Graphite). High-quality graphene is very strong, light, nearly transparent, and an excellent conductor of heat and electricity. Its interaction with other materials and with light, and its inherently two-dimensional nature, produce unique properties.

 At the time of its isolation in 2004, many researchers studying [carbon nanotubes](http://en.wikipedia.org/wiki/Carbon_nanotubes%22%20%5Co%20%22Carbon%20nanotubes) were already well familiar with the composition, structure and properties of graphene.

The combination of familiarity, extraordinary properties and surprising ease of isolation enabled an breakthrough in graphene research.

 Graphene is an [allotrope](http://en.wikipedia.org/wiki/Allotrope%22%20%5Co%20%22Allotrope) of [carbon](http://en.wikipedia.org/wiki/Carbon%22%20%5Co%20%22Carbon) whose structure is a single [planar](http://en.wikipedia.org/wiki/Plane_%28geometry%29%22%20%5Co%20%22Plane%20%28geometry%29) sheet of [sp](http://en.wikipedia.org/wiki/Sp2_bond%22%20%5Co%20%22Sp2%20bond)[2](http://en.wikipedia.org/wiki/Sp2_bond%22%20%5Co%20%22Sp2%20bond)[-bonded](http://en.wikipedia.org/wiki/Sp2_bond%22%20%5Co%20%22Sp2%20bond) carbon atoms, that are densely packed in a honeycomb crystal lattice. The term *graphene* was coined as a combination of [graphite](http://en.wikipedia.org/wiki/Graphite%22%20%5Co%20%22Graphite) and the suffix [-ene](http://en.wikipedia.org/wiki/-ene%22%20%5Co%20%22-ene) by [Hanns-Peter Boehm](http://en.wikipedia.org/wiki/Hanns-Peter_Boehm%22%20%5Co%20%22Hanns-Peter%20Boehm), who described single-layer carbon foils in 1962. Graphene is most easily visualized as an [atomic-scale chicken wire](http://en.wikipedia.org/wiki/Chicken_wire_%28chemistry%29%22%20%5Co%20%22Chicken%20wire%20%28chemistry%29) made of carbon atoms and their bonds.

 The [carbon-carbon bond](http://en.wikipedia.org/wiki/Carbon-carbon_bond%22%20%5Co%20%22Carbon-carbon%20bond) length in graphene is about 0.142 [nanometers](http://en.wikipedia.org/wiki/Nanometer%22%20%5Co%20%22Nanometer). Graphene sheets stack to form graphite with an interplanar spacing of 0.335 nm. Graphene is the basic structural element of some carbon allotropes including graphite, [charcoal](http://en.wikipedia.org/wiki/Charcoal%22%20%5Co%20%22Charcoal), [carbon nanotubes](http://en.wikipedia.org/wiki/Carbon_nanotube%22%20%5Co%20%22Carbon%20nanotube) and [fullerenes](http://en.wikipedia.org/wiki/Fullerene%22%20%5Co%20%22Fullerene). It can also be considered as an indefinitely large [aromatic](http://en.wikipedia.org/wiki/Aromaticity%22%20%5Co%20%22Aromaticity) molecule, the limiting case of the family of flat [polycyclic aromatic hydrocarbons](http://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbon%22%20%5Co%20%22Polycyclic%20aromatic%20hydrocarbon).

 Furthermore, a graphene sheet is thermodynamically unstable with respect to other [fullerene](http://en.wikipedia.org/wiki/Fullerene%22%20%5Co%20%22Fullerene) structures if its size is less than about 20 nm. The flat graphene sheet is also known to be unstable with respect to curling up, which is its lower-energy state. A definition of "isolated or free-standing graphene" has also recently been proposed: "graphene is a single atomic plane of graphite, which  – and this is essential – is sufficiently isolated from its environment to be considered free-standing."

**Unit 11**

**Scientific collocations of the terms:**

**heat and energy**

**Energy:**

**Verbs:**  to release - выделять, to consume – потреблять, to provide, to supply - обеспечивать, to store - хранить, to conserve, to save - сберегать.

**Adjectives:** Green energy – энергия, полученная экологически чистым методом, природосберегающая возобновляемая энергия, clean energy.

**Gas:**  noxious - вредный, to produce, to emit, to give off, to release - выделять, to evolve - выделяться (образовываться).

**Heat:** to evolve – выделяться (образовываться), to release – выделять, evolution - выделение, с выделением - with the evolution of.

Measures

Эта труба 3 метра длиной и 3 метра шириной. – This pipe is 3 meter long and 3 meter wide.

Толщина этого слоя 3 нм. - The thickness of this layer is 3 nm.

Этот слой **толщиной в 3 нм**. – This layer is **3 nm thick.**

**Exercise 1**  Fill the gaps with the following words: green energy, to release, noxious, to store, to consume, energy, gas, evolution, to give off, heat.

1. These days many countries try to use environmentally –friendly energy which is often called \_\_\_\_\_.
2. Chlorine is considered to be a \_\_\_\_gas which can cause health problems if it is inhaled.
3. Endothermic reactions \_\_\_\_\_ large amounts of energy.
4. Our researchers have developed new types of batteries which can \_\_\_\_large amounts of energy.
5. This reaction releases a lot of \_\_\_\_.
6. This process occurs with the \_\_\_\_\_evolution.
7. Water-chlorine reactions \_\_\_\_\_ gas.
8. Mobile phones \_\_\_\_ a lot of energy.
9. This process resulted in heat \_\_\_\_.

**Exercise 2**  Correct the mistakes in the expressions of measurement

1. The thick of layer is 5 nm.
2. What is the wide of this pipe ?
3. This wave is 3 cm length.
4. Yesterday we measured the parameters of this carbon tube which was 10 nm width.
5. The wing of this plane is 6 cm width and 7 m length.
6. The high of this carbon nanotube is 3 cm.
7. This nanotube is 3 cm height.

**Exercise 3**  Make up 5 sentences with each of the following words: heat, energy, gas.

Vocabulary

lattice - решетка

flexible molecules - гибкие молекулы

assume - принимать

conformation - форма

density - плотность

solid - твердое тело

X-ray examination - рентгеноскопия

solubility - растворимость

melting point - температура плавления

impose - накладывать

constraint - ограничение

molecular species - молекулярные частицы

hydrated - гидратированный

solvated - сольватированный

ribofuranose tetraacetate - терацетат рибофуранозы

stearoyl - стеароил

oleoyl - олеоил

palmitoyl - пальмитоил

X-ray diffraction - рентгеновская дифракция

improper storage - неправильное хранение

**Text**

**Translate and put 10 questions on the content of the text**

#### Polymorphism

 Polymorphs of a compound are different crystal forms in which the lattice arrangement of molecules are dissimilar. These distinct solids usually have different melting points, solubilities, densities and optical properties. Many polymorphic compounds have flexible molecules that may assume different conformations, and X-ray examination of these solids shows that their crystal lattices impose certain conformational constraints. When melted or in solution, different polymorphic crystals of this kind produce the same rapidly equilibrating mixture of molecular species. Polymorphism is similar to, but distinct from, hydrated or solvated crystalline forms. It has been estimated that over 50% of known organic compounds may be capable of polymorphism.

 The ribofuranose tetraacetate, was the source of an early puzzle involving polymorphism. The compound was first prepared in England in 1946, and had a melting point of 58 ºC. Several years later the same material, having the same melting point, was prepared independently in Germany and the United States. The American chemists then found that the melting points of their early preparations had risen to 85 ºC. Eventually, it became apparent that any laboratory into which the higher melting form had been introduced was no longer able to make the lower melting form. Microscopic seeds of the stable polymorph in the environment inevitably directed crystallization to that end. X-ray diffraction data showed the lower melting polymorph to be monoclinic, space group P2. The higher melting form was orthorhombic. Polymorphism has proven to be a critical factor in pharmaceuticals, solid state pigments and polymer manufacture. A common example of changes in polymorphism is shown by chocolate that has suffered heating and/or long storage. Over time, or when it resets after softening, it may have white patches on it, no longer melts in your mouth, and doesn't taste as good as it should. This is because chocolate has more than six polymorphs, and only one is ideal as a confection. It is created under carefully-controlled factory conditions. Improper storage or transport conditions cause chocolate to transform into other polymorphs.
Chocolate is in essence cocoa mass and sugar particles suspended in a cocoa butter matrix. Cocoa butter is a mixture of triglycerides in which stearoyl, oleoyl and palmitoyl groups predominate. It is the polymorphs of this matrix that influence the quality of chocolate. Low melting polymorphs feel too sticky or thick in the mouth. Form V, the best tasting polymorph of cocoa butter, has a melting point of 34 to 36 ºC, slightly less than the interior of the human body, which is one reason it melts in the mouth. Unfortunately, the higher melting form VI is more stable and is produced over time.

**Unit 12**

 **Adjective collocations for term description**

**Low, high, average:**  energy, temperature, pressure, density, volume.

**Small, large, average:** amount, quantity, volume.

**Soluble:** highly – soluble or very soluble – хорошо растворимый, readily/freely / easily soluble – легко растворимый, sparingly - soluble – плохо растворимый, poorly soluble – слаборастворимый, completely, fully soluble – полностью растворимый, hard-soluble – трудно растворимый.

**Collocations for graph description**

Построить кривую - to plot a curve

На графике - on a graph

Построить график - to draw, to construct, to create, to produce a graph,

Изобразить на графике - to plot smth. on a graph

График показывает - graph shows, indicates, represent smth

Представлять, показывать что-то на графике - to show, to represent smth. on a graph

 **Exercise 1**  Fill the gaps with the following words: large, readily-soluble, high, volume, pressure, to plot, indicate, curve

1. Lactic acid is considered to be a \_\_\_\_substance.
2. Unfortunately temperature was too \_\_\_\_.
3. Argon flame burns at an average \_\_\_\_.
4. The \_\_\_\_of this jar is large enough.
5. The \_\_\_\_amount of water was used in this experiment.
6. We tried to \_\_\_\_these changes on the graph.
7. The \_\_\_which we plotted yesterday didn’t show the increase of the yield.
8. The graph \_\_\_\_the stages of soot formation.

**Exercise 2** Correct the lexical mistakes in the sentences

1. This process ran at a very big temperature.
2. Unfortunately the volume of this flask is not great enough to use it in our experiment.
3. Last time we build a graph to show how the temperature changed during the experiment.
4. Unfortunately we weren’t able to form a graph which would fully reflect all fluctuations taking place during argon-flame burning.
5. Formic acid is a good-soluble substance.
6. Methylparabene is a difficultly -soluble substance.
7. Propylene glycol is a baldy -soluble substance in water.

**Exercise 3** Make up 1 sentence with the each of the following words: volume, large, small, average, high.

**Vocabulary**

 explosive - взрывчатое вещество

 release of heat - выделение тепла

 to propagate - распространяться

[nitroglycerin](http://en.wikipedia.org/wiki/Nitroglycerin%22%20%5Co%20%22Nitroglycerin) - нитроглицерин

 grain dust - зерновая пыль

 to expand -расширятся

 generation - образование

[nitrocellulose](http://en.wikipedia.org/wiki/Nitrocellulose%22%20%5Co%20%22Nitrocellulose) - нитроцеллюлоза

smokeless - не дающий дым

strength - прочность

 to explode - взрываться

speed- скорость

sensitive - чувствительный

high explosive - дробящее взрывчатое вещество

low explosive - метательное взрывчатое вещество

 [pressurized](http://en.wikipedia.org/wiki/Pressure%22%20%5Co%20%22Pressure) [gas](http://en.wikipedia.org/wiki/Gas_compressor%22%20%5Co%20%22Gas%20compressor) - сжатый газ

nuclear energy -ядерная энергия

[gelignite](http://en.wikipedia.org/wiki/Gelignite%22%20%5Co%20%22Gelignite) - гелигнит

 primary explosive - инициирующее взрывчатое вещество

secondary explosive - бризантное (вторичное) взрывчатое вещество

tertiary - третичный

 production - выделение

[trinitrotoluene](http://en.wikipedia.org/wiki/Trinitrotoluene%22%20%5Co%20%22Trinitrotoluene) - тринитротолуол

naval shell - военно-морской снаряд

**Text**

**Translate and put 10 questions on the content of the text**

**What is an explosive?**

 An explosion is a type of spontaneous chemical reaction that, once initiated, is driven by both a large exothermic change (great release of heat) and a large positive [entropy](http://en.wikipedia.org/wiki/Entropy%22%20%5Co%20%22Entropy) change (great quantities of gases are released) in going from reactants to products, thereby constituting a thermodynamically favorable process in addition to one that propagates very rapidly. Thus, explosives are substances that contain a large amount of energy stored in [chemical bonds](http://en.wikipedia.org/wiki/Chemical_bonds%22%20%5Co%20%22Chemical%20bonds). The energetic stability of the gaseous products and hence their generation comes from the formation of strongly bonded species like carbon monoxide, carbon dioxide, and (di)nitrogen, which contain strong double and triple bonds having bond strengths of nearly 1 MJ/mole.An explosive material, also called an explosive, is a reactive substance that contains a great amount of potential energy that can produce an [explosion](http://en.wikipedia.org/wiki/Explosion%22%20%5Co%20%22Explosion) if released suddenly, usually accompanied by the production of [light](http://en.wikipedia.org/wiki/Light%22%20%5Co%20%22Light), [heat](http://en.wikipedia.org/wiki/Heat%22%20%5Co%20%22Heat), [sound](http://en.wikipedia.org/wiki/Sound%22%20%5Co%20%22Sound), and [pressure](http://en.wikipedia.org/wiki/Pressure%22%20%5Co%20%22Pressure). An explosive charge is a measured quantity of explosive material.This potential energy stored in an explosive material may be:

* [chemical energy](http://en.wikipedia.org/wiki/Chemical_energy%22%20%5Co%20%22Chemical%20energy), such as [nitroglycerin](http://en.wikipedia.org/wiki/Nitroglycerin%22%20%5Co%20%22Nitroglycerin) or [grain dust](http://en.wikipedia.org/wiki/Grain_dust%22%20%5Co%20%22Grain%20dust);
* [pressurized](http://en.wikipedia.org/wiki/Pressure%22%20%5Co%20%22Pressure) [gas](http://en.wikipedia.org/wiki/Gas_compressor%22%20%5Co%20%22Gas%20compressor), such as a [gas cylinder](http://en.wikipedia.org/wiki/Gas_cylinder%22%20%5Co%20%22Gas%20cylinder) or [aerosol can](http://en.wikipedia.org/wiki/Aerosol_can%22%20%5Co%20%22Aerosol%20can);
* [nuclear](http://en.wikipedia.org/wiki/Nuclear_weapon%22%20%5Co%20%22Nuclear%20weapon) energy, such as in the [fissile](http://en.wikipedia.org/wiki/Fissile%22%20%5Co%20%22Fissile) [isotopes](http://en.wikipedia.org/wiki/Isotope%22%20%5Co%20%22Isotope) [uranium-235](http://en.wikipedia.org/wiki/Uranium-235%22%20%5Co%20%22Uranium-235) and [plutonium-239](http://en.wikipedia.org/wiki/Plutonium-239%22%20%5Co%20%22Plutonium-239).

 Explosive materials may be categorized by the speed at which they expand. Materials that [detonate](http://en.wikipedia.org/wiki/Detonate%22%20%5Co%20%22Detonate) (explode faster than the [speed of sound](http://en.wikipedia.org/wiki/Speed_of_sound%22%20%5Co%20%22Speed%20of%20sound)) are said to be "high explosives" and materials that [deflagrate](http://en.wikipedia.org/wiki/Deflagrate%22%20%5Co%20%22Deflagrate) are said to be "low explosives". Explosives may also be categorized by their [sensitivity](http://en.wikipedia.org/wiki/Sensitivity_%28explosives%29%22%20%5Co%20%22Sensitivity%20%28explosives%29). Sensitive materials that can be initiated by a relatively small amount of heat or pressure are [primary explosives](http://en.wikipedia.org/wiki/Explosive_material%22%20%5Cl%20%22Primary_explosive%22%20%5Co%20%22Explosive%20material) and materials that are relatively insensitive are [secondary](http://en.wikipedia.org/wiki/Secondary_explosives%22%20%5Co%20%22Secondary%20explosives) or [tertiary explosives](http://en.wikipedia.org/wiki/Explosive_material%22%20%5Cl%20%22Tertiary_explosive%22%20%5Co%20%22Explosive%20material). A wide variety of chemicals can explode;

 Though [early thermal weapons](http://en.wikipedia.org/wiki/Early_thermal_weapons%22%20%5Co%20%22Early%20thermal%20weapons), such as [Greek fire](http://en.wikipedia.org/wiki/Greek_fire%22%20%5Co%20%22Greek%20fire), have existed since ancient times, the first widely used explosive in [warfare](http://en.wikipedia.org/wiki/Warfare%22%20%5Co%20%22Warfare) and [mining](http://en.wikipedia.org/wiki/Mining%22%20%5Co%20%22Mining) was [black powder](http://en.wikipedia.org/wiki/Black_powder%22%20%5Co%20%22Black%20powder), invented in 9th century China. This material was sensitive to water, and evolved lots of dark smoke. The first useful explosive stronger than black powder was [nitroglycerin](http://en.wikipedia.org/wiki/Nitroglycerin%22%20%5Co%20%22Nitroglycerin), developed in 1847.

 As nitroglycerin was unstable, it was replaced by [nitrocellulose](http://en.wikipedia.org/wiki/Nitrocellulose%22%20%5Co%20%22Nitrocellulose), [smokeless powder](http://en.wikipedia.org/wiki/Smokeless_powder%22%20%5Co%20%22Smokeless%20powder), [dynamite](http://en.wikipedia.org/wiki/Dynamite%22%20%5Co%20%22Dynamite) and [gelignite](http://en.wikipedia.org/wiki/Gelignite%22%20%5Co%20%22Gelignite) (the two latter invented by [Alfred Nobel](http://en.wikipedia.org/wiki/Alfred_Nobel%22%20%5Co%20%22Alfred%20Nobel)). World War I saw the introduction of [trinitrotoluene](http://en.wikipedia.org/wiki/Trinitrotoluene%22%20%5Co%20%22Trinitrotoluene) in naval shells.

**Unit 13**

**Attributive Chains with a Hyphen**

 E.g.: filter –based method, electric-field-induced modifications – **lexical unfolding**.

Stage I: Lexical unfolding

filter –based method – method based on filter – метод;

electric-field-induced modifications – modifications induced by electric field;

Stage II: translation using subordinate clause with the word: который:

Метод, который основывается на использовании фильтра.

 However there are other types of such kind chains the first version of which can include the clause with which or participle I. For instance: The mixtures which contain boron or mixtures containing boron. To convert such kind compound phrases into compact phrase we should do the following stages:

Stage I: if we have a clause with the word: which we should omit the word: which and turn the verb that stands after it into Participle I; if we have a phrase with participle I we shouldn’t do this operation, for instance:

The compounds which contain cobalt – the compounds containing cobalt

Stage II: then we should change the order in this phrase. At the beginning we should put the word which is the last in the initial phrase, then we should put a hyphen, after that we should put Participle I and the word which was the first in the initial phrase should become the last one. For instance:

Cobalt - containing compounds

 **Exercise 1** Convert the following phrases into attributive chains with a hyphen: carbon nanotubes generated by deposition, extinction triggered by laser, reaction between water and gas, interaction of chlorine with oxygen, soot generated by combustion, particles selected by a size, measurement based on calibration, changes induced by magnetic fluctuation, compounds containing sulhpur , reactions substituting hydrochloric acid.

**Exercise 2** Correct the mistakes in the attributive chains with a hyphen

1. Substances - containing - chlorine
2. Reactions - hydrogen - oxygen
3. Dependent - size - curve
4. Based on - measurements - laser extinction
5. Argon addition - flame shape changes - induced by
6. Measurements - based - laser diagnostics
7. Compounds - produced - synthesis
8. Size changes - calibration- determined

**Exercise 3** Give the definitions for the following terms: a reaction, sulphur, electric field, a compound.

Vocabulary

oil – нефть

crude oil - сырая нефть

natural gas - природный газ

sour crude oil - высокосернистая сырая нефть

sour natural gas - высокосернистый природный газ

light crude oil - легкая нефть, парафиновая нефть

heavy crude oil - тяжелая нефть

fluid, liquid - жидкость

fluid -текучий

valuable - ценный

hydrogen sulfide - сероводород

thick - густой

viscous - вязкий

a commercial deposit - месторождение, пригодное для разработки

sedimentary rock - осадочная порода

a layer - слой

subsurface reservoir - залежь под поверхностью, подземное газохранилище

sand grains - песчинки

to be composed of - состоять

seashells - морская ракушка

breakdown - раскол, распад

to make up - составлять

 to precipitate - осаждаться

sediment - отложение, осадок

 to drill - бурить

**Text**

**Translate and put 10 questions on the content of the text**

**General characteristic of oil and gas**

Both crude oil and natural gas are mixtures of molecules formed by carbon and hydrogen atoms. There are many different types of crude oils and natural gases, some more valuable than others. Heavy crude oils are very thick and viscous and are difficult or impossible to produce, whereas light crude oils are very fluid and relatively easy to produce. Less valuable are sour crude oils that contain sulfur and sour natural gasses that contain hydrogen sulfide. Some natural gases that burn with more heat than others, contain natural gas liquids and gasoline, and are more valuable.

In order to have a commercial deposit of gas or oil, three geological conditions must have been met. First, there must be a source rock in the subsurface of that area that generated the gas or oil at some time in the geological past. Second, there must be a separate, subsurface reservoir rock to hold the gas or oil. Third, there must be a trap on the reservoir rock to concentrate the gas or oil into commercial quantities.

The uppermost crust of the earth in oil- and gas-producing areas is composed of

sedimentary rock layers. Sedimentary rocks are the source and reservoir rocks for gas and oil. These rocks are called sedimentary rocks because they are composed of sediments. Sediments are 1) particles such as sand grains that were formed by the breakdown of pre-existing rocks and, 2) seashells, or 3) salt that precipitated from of water. The sedimentary rocks that make up the earth’s crust are millions and sometimes billions of years old. During the vast expanse of geological time, sea level has not been constant. Many times in the past, the seas have risen to cover the land and then fallen to expose the land. During these times, sediments were deposited. These sediments are relatively simple materials such as sands deposited along beaches, mud on the sea bottom, and beds of sea-shells. These ancient sediments, piled layer upon layer, form the sedimentary rocks that are drilled to find and produce oil and gas.

**Unit 14**

**Gerund constructions with**

**In, On (upon), after and before**

 The conjunctions such as after, before, on (upon) and in are often used in scientific texts and after them we can use gerund constructions. For example: After adding the water we analyzed the composition of the solution.

**Active Voice**

|  |  |
| --- | --- |
| After we added some water we obtained a new solution.  | After adding some water we obtained a new solution  |
| On (upon) analysis we found new properties.  | On (upon) analyzing we found new properties.  |
| Before we carried an experiment we measured all parameters.  | Before carrying an experiment we measured all parameters.  |
| In the determination of these parameters we found some uncertainties  | In determining these parameters we found some uncertainties  |

**Passive Voice**

|  |  |
| --- | --- |
| After the water was added it dissolved in the solution.  | After being added the water it dissolved in the solution  |
| On (upon) analysis of this substance it exhibited new properties.  | On (upon) being analyzed the substance exhibited new properties.  |
| Before the experiment was carried out it was discussed.  | Before being carried out the experiment was discussed.  |
| In the study this mixtures changed the color.  | Doesn’t change  |

**Exercise 1** Remake the following sentences using gerund constructions in Active Voice. For example: Before we started writing an article we made research. – Before starting writing an article we made research.

1. After we measured the pressure we started a new stage of the experiment.
2. Before we introduced these components into the mixture we thoroughly investigated their properties.
3. In the study of chlorine properties we were able to obtain new chlorine compounds.
4. On the cooling of this substance we changed the parameters.
5. After we heated this substance we could see how the substance turned red.
6. Before we dissolved this substance in the water we checked its solubility.
7. After we measured the temperature we found a new value.
8. After we produced a new type of carbon particle we studied its properties.
9. Before we placed the substance obtained under into the water jacket we checked the conditions.

**Exercise 2** Remake the following sentences using gerund constructions in Passive Voice.

1. After the substance was obtained it was studied.
2. Before the substance was cooled it was placed under the nitrogen shroud.
3. After the substance was weighed it was diluted at a high temperature in hydrochloric acid.
4. After the acid mantle was found it was studied.
5. Before sulfur was burnt it was placed into the flask.
6. After boron oxide was investigated under the microscope it was added to the solution.
7. Before lactic acid was dissolved it was stored in the cold place.
8. Before fumaric acid was used in the production it was studied by our researchers.
9. After the salts were heated they decomposed.
10. After the report was discussed it was published.
11. Before the graph was drawn it was planned by us.
12. Before the catalyst was introduced it was analyzed.

**Exercise 3** Fill the gaps using on, in, after and before

1. \_\_\_\_\_\_\_drawing the curve we obtained these data.
2. \_\_\_\_\_\_being cooled the substance was added to the solution.
3. \_\_\_\_\_the study of lactic acid we found new application for this acid.
4. \_\_\_\_\_\_finishing an experiment we decided to write an article.

**Vocabulary**

surface - поверхность

route - путь, маршрут

reservoir rock - пористая порода, нефтесодержащая порода

angle - угол

flow - течь

fluid - жидкость

dome - купол

anticline - антиклиналь

encounter a trap - попасть в ловушку

permeability - проницаемость

sedimentary rock - осадочная порода

seal - непроницаемая порода, уплотнение, покрышка

to seal - закрывать, придавать непроницаемость

shale - сланец

 to leak up - вытекать

**Text**

**Translate and put 10 questions on the content of the text**

**Oil migration**

 Any fluid (water, gas, or oil), either on the surface or in the subsurface, will always flow along the path of the least resistance, the easiest route. In the subsurface, the path of least resistance is along a reservoir rock layer. This is because most of the pore spaces are interconnected, and the fluid can flow from pore to pore. The ease in which the fluid can flow through the rock is called permeability, and the movement of the gas and oil up the angle of the reservoir rock toward the surface is called migration. Because of migration, the gas and oil can end up a considerable distance, both vertically and horizontally, from where it was originally formed.

As the gas and oil migrates up along the reservoir rock, it can encounter a trap. A trap is a high point in the reservoir rock where the gas or oil is stopped and concentrated. Because the pores in the reservoir rock are filled with water, the gas and oil will flow to the highest part of the reservoir rock.

One type of trap is a natural arch in the reservoir rock called a dome or anticline.

In the trap, the fluids separate according to their density. The gas is the lightest and goes to the top of the trap to form the free gas cap. The oil goes to the middle to form the oil reservoir. The salt water, the heaviest goes to the bottom.

To complete the trap, a cap rock must overlie the reservoir rock. The cap rock is sealed and doesn’t allow fluids to flow through it. Without a cap rock, the oil and gas would leak up to the surface of the ground. Two common sedimentary rocks that can be seals are shale and salt.

**Unit 15**

**Scientific collocation with the words:**

**Equation**

**and the use of the verb: result**

**in scientific texts**

**Equation - уравнение:**

**Adjective + equation**

Simple equation - простое уравнение

Basic equation - основное уравнение

Complex, complicated equation - сложное уравнение

**Verb + equation**

To solve equation - решить уравнение

To work out equation - составить уравнение

To write equation - написать уравнение

To obtain, to derive equation - получить (вывести) уравнение

To balance equation - сбалансировать уравнение

**To result in + Ving or noun**

To result in + Ving

 В результате этого исследования были найдены новые формы этого вещества. - As a result of this study new species of this substance were found. = This study resulted in finding new species of this substance.

To result in + noun

В результате этого процесса образовалось новое соединение. - This process resulted in the formation of new compound.

На основании - to result in

На основании этих статей было проведено много экспериментов. - These articles resulted in many experiments.

**Exercise 1**  Fill the gaps using the following words: equation, simple, to derive (2 times), complex.

1. This \_\_\_\_\_is difficult to balance.
2. I think this problem is very \_\_\_\_. We solved it for two minutes.
3. Unfortunately we weren’t able to \_\_\_\_\_an equation for this value.
4. Yesterday at the math lesson’s we tried to \_\_\_\_an equation for obtain this magnitude.
5. I must admit that this problem is too\_\_\_\_for us. We have been discussing for 3 hours and can’t come to the final conclusion.

**Exercise 2** Paraphrase the following sentences using the verb: to result in

1. As a result of these studies the substance was produced.
2. This solution of this problem gave a new method for the low-cost production of nanocrystals.
3. The carbon compound was found as a result of the independent synthesis.
4. As a result of the reaction between oxygen and hydrogen the new liquid was obtained.
5. The discussion of this issue caused many arguments.
6. As a result of the addition of nitric acid the solution turned green.
7. As a result of the addition of argon the flame started burning.
8. As a result of the investigation lithium batteries were obtained.
9. Boric acid addition triggered the change of the reaction rate.
10. The use of copper allowed obtaining new types of polymer.

**Exercise 3** Give the definitions for the following words: equation, result, substance, compound.

**Vocabulary**

petroleum - нефть

composition - состав

to include - включать

hydrocarbon - углеводород

however - тем не менее

 to range - колебаться

size - размер

fossil fuel - ископаемое топливо

coal - уголь

sulfur - сера

refining - очистка, переработка

refiner - специалист по нефтепереработке

to remove - удалять

sour - содержащий серу

 sweet - обессеренный, не содержащий активных соединений серые

 light oil - легкие фракции нефти, светлый нефтепродукт, дизельное топливо

 heavy oil - тяжелая нефть, необработанная нефть

 to process - перерабатывать

 content - содержание

refinery - нефтеперерабатывающий завод

**Text**

**Translate and put 10 questions on the content of the text**

 **Petroleum, Chemical Composition, Properties**

The word petroleum comes from the Greeks. Petro means rock, and oleum means oil. In it strictest sense, petroleum includes only crude oil. By usage, however, petroleum includes both crude oil and natural gas. The two most important elements in both crude oil and natural gas are carbon and hydrogen. Because of this, crude oil and natural gas are called hydrocarbons*.* The difference between crude oil and natural gas is the size of the hydrocarbon molecules. Under surface temperature and pressure, any hydrocarbon molecule that has one, two, three, or four carbon atoms occurs as a gas. Natural gas is composed of a mixture of the four short hydrocarbon molecules. Any hydrocarbon molecule with five or more carbon atoms occurs as a liquid. Crude oil is a mixture of more than 100 hydrocarbon molecules that range in size from 5 to more than 60 carbons in length. The hydrocarbon molecules in oil form straight chains, chains with side branches, and circles.

Sulfur is an undesirable impurity in fossil fuels such as crude oil, natural gas, and coal. When sulfur is burned, it forms sulfur dioxide, a gas that pollutes the air and forms acid rain. During the refining process, the refiner must remove the sulfur as the crude oil is being processed. If not, the sulfur will harm some of the chemical equipment in the refinery. Crude oils are classified as sweet and sour on the basis of their sulfur content. Sweet crudes have less than 1% sulfur by weight, whereas sour crudes have more than 1% sulfur. In general, heavy oils tend to be sour, whereas light oils tend to be sweet. At a refinery, low sulfur crude has 0 to 0.6% sulfur. Intermediate sulfur crude has 0.6 to 1.7% sulfur, and high sulfur crude has above 1.7% sulfur. Most of the sulfur in crude oil occurs bonded to the carbon atoms. A very small amount can occur as elemental sulfur in solution and as H2S gas.

**Text for additional reading**

**Carbon fibers**

 Carbon fiber is a material consisting of [fibers](http://en.wikipedia.org/wiki/Fibers%22%20%5Co%20%22Fibers) about 5–10 μm in diameter and composed mostly of [carbon](http://en.wikipedia.org/wiki/Carbon%22%20%5Co%20%22Carbon) atoms. The carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber. The crystal alignment gives the fiber high strength-to-volume ratio (making it strong for its size). Several thousand carbon fibers are bundled together to form a [tow](http://en.wikipedia.org/wiki/Tow%22%20%5Co%20%22Tow), which may be used by itself or [woven](http://en.wikipedia.org/wiki/Woven%22%20%5Co%20%22Woven) into a fabric.

 The properties of carbon fibers, such as high stiffness, high tensile strength, low weight, high chemical resistance and low thermal expansion, make them very popular in aerospace and civil engineering. However, they are relatively expensive when compared to similar fibers, such as [glass fibers](http://en.wikipedia.org/wiki/Glass_%28fiber%29%22%20%5Co%20%22Glass%20%28fiber%29) or plastic fibers.

Carbon fibers are usually combined with other materials to form a [composite](http://en.wikipedia.org/wiki/Composite_material%22%20%5Co%20%22Composite%20material). However, carbon fibers are also composed with other materials, such as with graphite to form carbon-carbon composites.The atomic structure of carbon fiber is similar to that of [graphite](http://en.wikipedia.org/wiki/Graphite%22%20%5Co%20%22Graphite), consisting of sheets of carbon [atoms](http://en.wikipedia.org/wiki/Atoms%22%20%5Co%20%22Atoms) ([graphene](http://en.wikipedia.org/wiki/Graphene%22%20%5Co%20%22Graphene) sheets) arranged in a regular [hexagonal](http://en.wikipedia.org/wiki/Hexagon%22%20%5Co%20%22Hexagon) pattern. Carbon fiber is most notably used to reinforce [composite materials](http://en.wikipedia.org/wiki/Composite_material%22%20%5Co%20%22Composite%20material), particularly the class of materials known as [carbon fiber or graphite reinforced polymers](http://en.wikipedia.org/wiki/Carbon_fiber_reinforced_polymer%22%20%5Co%20%22Carbon%20fiber%20reinforced%20polymer). Non-polymer materials can also be used as the matrix for carbon fibers. [Reinforced carbon-carbon](http://en.wikipedia.org/wiki/Reinforced_carbon-carbon%22%20%5Co%20%22Reinforced%20carbon-carbon) (RCC) consists of carbon fiber-reinforced graphite, and is used structurally in high-temperature applications. The fiber also finds use in [filtration](http://en.wikipedia.org/wiki/Filtration%22%20%5Co%20%22Filtration) of high-temperature gases, as an [electrode](http://en.wikipedia.org/wiki/Electrode%22%20%5Co%20%22Electrode) with high surface area and impeccable [corrosion](http://en.wikipedia.org/wiki/Corrosion%22%20%5Co%20%22Corrosion) resistance, and as an anti-[static](http://en.wikipedia.org/wiki/Triboelectric_effect%22%20%5Co%20%22Triboelectric%20effect) component. Molding a thin layer of carbon fibers significantly improves fire resistance of polymers or thermoset composites because a dense, compact layer of carbon fibers efficiently reflects heat.

**Graphite**

 The [mineral](http://en.wikipedia.org/wiki/Mineral%22%20%5Co%20%22Mineral) graphite is an [allotrope of carbon](http://en.wikipedia.org/wiki/Allotrope_of_carbon%22%20%5Co%20%22Allotrope%20of%20carbon). Unlike [diamond](http://en.wikipedia.org/wiki/Diamond%22%20%5Co%20%22Diamond) (another carbon allotrope), graphite is an [electrical conductor](http://en.wikipedia.org/wiki/Electrical_conductor%22%20%5Co%20%22Electrical%20conductor), a [semimetal](http://en.wikipedia.org/wiki/Semimetal%22%20%5Co%20%22Semimetal). Graphite is the most stable form of carbon under [standard conditions](http://en.wikipedia.org/wiki/Standard_conditions%22%20%5Co%20%22Standard%20conditions). Therefore, it is used in thermochemistry as the [standard state](http://en.wikipedia.org/wiki/Standard_state%22%20%5Co%20%22Standard%20state) for defining the [heat of formation](http://en.wikipedia.org/wiki/Standard_enthalpy_of_formation%22%20%5Co%20%22Standard%20enthalpy%20of%20formation) of carbon compounds. Graphite may be considered the highest grade of [coal](http://en.wikipedia.org/wiki/Coal%22%20%5Co%20%22Coal), just above [anthracite](http://en.wikipedia.org/wiki/Anthracite%22%20%5Co%20%22Anthracite) and alternatively called meta-anthracite, although it is not normally used as fuel because it is difficult to ignite.

 There are two principal types of natural graphite, each occurring in different types of [ore](http://en.wikipedia.org/wiki/Ore%22%20%5Co%20%22Ore) deposit:

* Crystalline flake graphite (or flake graphite for short) occurs as isolated, flat, plate-like particles with [hexagonal](http://en.wikipedia.org/wiki/Hexagon%22%20%5Co%20%22Hexagon) edges;
* *Amorphous* graphite occurs as fine particles and is the result of [thermal metamorphism](http://en.wikipedia.org/wiki/Thermal_metamorphism%22%20%5Co%20%22Thermal%20metamorphism) of coal, the last stage of [coalification](http://en.wikipedia.org/w/index.php?title=Coalification&action=edit&redlink=1" \o "Coalification (page does not exist)), and is sometimes called meta-anthracite.

 Highly ordered pyrolytic graphite or highly *oriented* pyrolytic graphite (HOPG) refers to graphite with an angular spread between the graphite sheets of less than 1°. This highest-quality synthetic form is used in scientific research, in particular, as a standard for calibration of [scanning probe microscopes](http://en.wikipedia.org/wiki/Scanning_probe_microscope%22%20%5Co%20%22Scanning%20probe%20microscope). The name "graphite fiber" is also sometimes used to refer to [carbon fiber](http://en.wikipedia.org/wiki/Carbon_%28fiber%29%22%20%5Co%20%22Carbon%20%28fiber%29) or [carbon fiber-reinforced polymer](http://en.wikipedia.org/wiki/Carbon_fiber-reinforced_polymer%22%20%5Co%20%22Carbon%20fiber-reinforced%20polymer).

Graphite has a layered, planar structure. In each layer, the carbon atoms are arranged in a [honeycomb lattice](http://en.wikipedia.org/wiki/Honeycomb_lattice%22%20%5Co%20%22Honeycomb%20lattice) with separation of 0.142 nm, and the distance between planes is 0.335 nm. The two known forms of graphite, *alpha* (hexagonal) and *beta* ([rhombohedral](http://en.wikipedia.org/wiki/Rhombohedral%22%20%5Co%20%22Rhombohedral)), have very similar physical properties, except that the [graphene](http://en.wikipedia.org/wiki/Graphene%22%20%5Co%20%22Graphene) layers stack slightly differently. The hexagonal graphite may be either flat or buckled. The alpha form can be converted to the beta form through mechanical treatment and the beta form reverts to the alpha form when it is heated above 1300 °C.

**Nanocrystal**

 A nanocrystal is a [crystalline](http://en.wikipedia.org/wiki/Crystalline%22%20%5Co%20%22Crystalline) [nanoparticle](http://en.wikipedia.org/wiki/Nanoparticle%22%20%5Co%20%22Nanoparticle). Some sources define it as any [singlecrystalline](http://en.wikipedia.org/w/index.php?title=Singlecrystalline&action=edit&redlink=1" \o "Singlecrystalline (page does not exist)) [nanomaterial](http://en.wikipedia.org/wiki/Nanomaterial%22%20%5Co%20%22Nanomaterial) with at least one dimension ≤ 100 nm., while others define it as a [nanoparticle](http://en.wikipedia.org/wiki/Nanoparticle%22%20%5Co%20%22Nanoparticle) with any kind of [crystalline](http://en.wikipedia.org/wiki/Crystalline%22%20%5Co%20%22Crystalline) structure.

 A material object that measures less than 1 micrometre, i.e., 1000 nanometers in all dimensions is a [nanoparticle](http://en.wikipedia.org/wiki/Nanoparticle%22%20%5Co%20%22Nanoparticle), not a nanocrystal. Only single-crystalline or polycrystalline materials are nanocrystals.

Silicon nanocrystals can provide efficient light emission even while bulk Silicon does not and can be used for memory components. Nanocrystals embedded in solids can exhibit much more complex melting behaviour than conventional solids and can form the basis of a special class of solids.

 The traditional way to prepare nanocrystals of a new material involved choosing molecular precursors, surfactants, and solvents using optimized reaction conditions causing the atoms to self-assemble into monodisperse nanocrystals.

A newer, simpler strategy uses preformed nanocrystals as templates and chemical transformation to change the composition. Solution-based mechanisms can chemically transform nanomaterials, allowing atoms to be easily and precisely incorporated, removed, or replaced from preformed templates. The approach uses oxidation, reduction, alloying, or atomic exchange reactions. In ionic nanocrystals, cation exchange can be driven by solvation energy differences between template and solvated ions. Ion solubilities can be controlled by adding selective coordinating species to the solution. In metal nanocrystals, atomic exchange reactions reflect reduction potential differences between the template metal and solvated metal ions. This *galvanic replacement* method involves a [redox](http://en.wikipedia.org/wiki/Redox%22%20%5Co%20%22Redox) reaction. Placing a nanocrystal in a solution containing metal ions with a higher reduction potential oxidizes the templates' surface, dissolving its metal ions. The released electrons reduce the ions from the solution, which deposit at the template's surface.

 Galvanic replacement also applies to ionic compounds. In oxide nanocrystals, a redox-couple reaction can occur between multivalent metallic ions. E.g., higher–oxidation state ions in [manganese oxide](http://en.wikipedia.org/wiki/Manganese_oxide%22%20%5Co%20%22Manganese%20oxide) nanocrystals have been replaced with solvated lower–oxidation state iron ions.

**Silicon**

 Silicon is a [tetravalent](http://en.wikipedia.org/wiki/Tetravalent%22%20%5Co%20%22Tetravalent) [metalloid](http://en.wikipedia.org/wiki/Metalloid%22%20%5Co%20%22Metalloid), is a [chemical element](http://en.wikipedia.org/wiki/Chemical_element%22%20%5Co%20%22Chemical%20element) with the symbol Si and [atomic number](http://en.wikipedia.org/wiki/Atomic_number%22%20%5Co%20%22Atomic%20number) 14. It is less reactive than its [chemical analog](http://en.wikipedia.org/wiki/Structural_analog%22%20%5Co%20%22Structural%20analog) [carbon](http://en.wikipedia.org/wiki/Carbon%22%20%5Co%20%22Carbon), the [nonmetal](http://en.wikipedia.org/wiki/Nonmetal%22%20%5Co%20%22Nonmetal) directly above it in the [periodic table](http://en.wikipedia.org/wiki/Periodic_table%22%20%5Co%20%22Periodic%20table), but more reactive than [germanium](http://en.wikipedia.org/wiki/Germanium%22%20%5Co%20%22Germanium), the metalloid directly below it in the table; it was first prepared and characterized in pure form in 1823. Silicon is the eighth most [common element](http://en.wikipedia.org/wiki/Abundance_of_the_chemical_elements%22%20%5Co%20%22Abundance%20of%20the%20chemical%20elements) in the universe by mass, but very rarely occurs as the pure free element in nature. It is most widely distributed in [dusts](http://en.wikipedia.org/wiki/Dust%22%20%5Co%20%22Dust) as various forms of [silicon dioxide](http://en.wikipedia.org/wiki/Silicon_dioxide%22%20%5Co%20%22Silicon%20dioxide) (silica) or [silicates](http://en.wikipedia.org/wiki/Silicate%22%20%5Co%20%22Silicate). Over 90% of the Earth's crust is composed of [silicate minerals](http://en.wikipedia.org/wiki/Silicate_minerals%22%20%5Co%20%22Silicate%20minerals), making silicon the [second most abundant element](http://en.wikipedia.org/wiki/Abundance_of_elements_in_Earth%27s_crust%22%20%5Co%20%22Abundance%20of%20elements%20in%20Earth%27s%20crust) in the Earth's crust (about 28% by mass) after [oxygen](http://en.wikipedia.org/wiki/Oxygen%22%20%5Co%20%22Oxygen).

 Most silicon is used commercially without being separated, and indeed often with little processing of compounds from nature. These include direct industrial building-use of [clays](http://en.wikipedia.org/wiki/Clays%22%20%5Co%20%22Clays), [silica sand](http://en.wikipedia.org/wiki/Silica_sand%22%20%5Co%20%22Silica%20sand) and [stone](http://en.wikipedia.org/wiki/Stone%22%20%5Co%20%22Stone). Silica is used in [ceramic](http://en.wikipedia.org/wiki/Ceramic%22%20%5Co%20%22Ceramic) brick. Silicate goes into [Portland cement](http://en.wikipedia.org/wiki/Portland_cement%22%20%5Co%20%22Portland%20cement) for [mortar](http://en.wikipedia.org/wiki/Mortar_%28masonry%29%22%20%5Co%20%22Mortar%20%28masonry%29) and [stucco](http://en.wikipedia.org/wiki/Stucco%22%20%5Co%20%22Stucco), and when combined with silica sand and [gravel](http://en.wikipedia.org/wiki/Gravel%22%20%5Co%20%22Gravel), to make [concrete](http://en.wikipedia.org/wiki/Concrete%22%20%5Co%20%22Concrete). Silicates are also met in whiteware [ceramics](http://en.wikipedia.org/wiki/Ceramic%22%20%5Co%20%22Ceramic) such as [porcelain](http://en.wikipedia.org/wiki/Porcelain%22%20%5Co%20%22Porcelain), and in traditional [quartz](http://en.wikipedia.org/wiki/Quartz%22%20%5Co%20%22Quartz)-based [soda-lime glass](http://en.wikipedia.org/wiki/Soda-lime_glass%22%20%5Co%20%22Soda-lime%20glass). More modern silicon compounds such as [silicon carbide](http://en.wikipedia.org/wiki/Silicon_carbide%22%20%5Co%20%22Silicon%20carbide) form abrasives and high-strength ceramics. Silicon is the basis of the ubiquitous synthetic silicon-based polymers called [silicones](http://en.wikipedia.org/wiki/Silicone%22%20%5Co%20%22Silicone).

 Elemental silicon also has a large impact on the modern world economy. Although most free silicon is used in the [steel](http://en.wikipedia.org/wiki/Steel%22%20%5Co%20%22Steel) refining, [aluminum](http://en.wikipedia.org/wiki/Aluminum%22%20%5Co%20%22Aluminum)-casting, and fine chemical industries (often to make [fumed silica](http://en.wikipedia.org/wiki/Fumed_silica%22%20%5Co%20%22Fumed%20silica)), the relatively small portion of purified silicon is used in semiconductor electronics (< 10%). Because of wide use of silicon in [integrated circuits](http://en.wikipedia.org/wiki/Integrated_circuits%22%20%5Co%20%22Integrated%20circuits), the basis of most computers, a great deal of modern technology depends on it.

 Silicon is an essential element in biology. However, various [sea sponges](http://en.wikipedia.org/wiki/Sea_sponges%22%20%5Co%20%22Sea%20sponges) as well as microorganisms like [diatoms](http://en.wikipedia.org/wiki/Diatoms%22%20%5Co%20%22Diatoms) need silicon in order to have structure. It is much more important to the metabolism of plants, particularly many [grasses](http://en.wikipedia.org/wiki/Grasses%22%20%5Co%20%22Grasses).

**Detonation**

 Detonation involves a [supersonic](http://en.wikipedia.org/wiki/Supersonic%22%20%5Co%20%22Supersonic) exothermic front accelerating through a medium that eventually drives a [shock front](http://en.wikipedia.org/wiki/Shock_front%22%20%5Co%20%22Shock%20front) propagating directly in front of it. Detonations are observed in both conventional solid and liquid explosives, as well as in reactive gases. The [velocity of detonations](http://en.wikipedia.org/wiki/Detonation_velocity%22%20%5Co%20%22Detonation%20velocity) in solid and liquid explosives is much higher than that in gaseous ones, which allows the wave system to be observed with greater details.

 Gaseous detonations normally occur in confined systems but are occasionally observed in large vapor clouds. They are often associated with a gaseous mixture of fuel and oxidant of a composition, somewhat below conventional flammability limits. There is an extraordinary variety of fuels that may be present as gases and as dust suspensions. Other materials, such as acetylene, ozone and hydrogen peroxide are detonable in the absence of oxygen; a more complete list is given by both Stull and Bretherick. Oxidants include halogens, ozone, hydrogen peroxide and oxides of nitrogen. In terms of external damage, it is important to distinguish between detonations and [deflagrations](http://en.wikipedia.org/wiki/Deflagration%22%20%5Co%20%22Deflagration) where the exothermic wave is subsonic. Processes involved in the [transition between deflagration and detonation](http://en.wikipedia.org/wiki/Deflagration_to_detonation_transition%22%20%5Co%20%22Deflagration%20to%20detonation%20transition) are covered thoroughly for gasses by Nettleton. The simplest theory to predict the behavior of detonations in gases is known as [Chapman-Jouguet](http://en.wikipedia.org/wiki/Chapman-Jouguet_condition%22%20%5Co%20%22Chapman-Jouguet%20condition) (CJ) theory, developed around the turn of the 20th century. This theory, described by a relatively simple set of algebraic equations, models the detonation as a propagating shock wave accompanied by exothermic heat release.

Such a theory confines the chemistry and diffusive transport processes to an infinitely thin zone. A more complex theory was advanced during World War II independently by [Zel'dovich](http://en.wikipedia.org/wiki/Zel%27dovich%22%20%5Co%20%22Zel%27dovich), [von Neumann](http://en.wikipedia.org/wiki/Von_Neumann%22%20%5Co%20%22Von%20Neumann), and [W. Doering](http://en.wikipedia.org/wiki/W._Doering%22%20%5Co%20%22W.%20Doering). This theory admits finite-rate chemical reactions and thus describes a detonation as an infinitely thin shock wave followed by a zone of exothermic chemical reaction. There is also some evidence that the reaction zone is semi-metallic in some explosives. Both theories describe one-dimensional and steady wave fronts. However, in the 1960s, experiments revealed that gas-phase detonations were most often characterized by unsteady, three-dimensional structures, which can only in an averaged sense be predicted by one-dimensional steady theories. Indeed, such waves are quenched as their structure is destroyed.

### **Stability of explosives**

 Stability is the ability of an explosive to be stored without [deterioration](http://en.wikipedia.org/wiki/Chemical_decomposition%22%20%5Co%20%22Chemical%20decomposition). In the strictest technical sense, the word "stability" is a thermodynamic term referring to the energy of a substance relative to a reference state or to some other substance. However, in the context of explosives, stability commonly refers to ease of detonation, which is concerned with [kinetics](http://en.wikipedia.org/wiki/Chemical_kinetics%22%20%5Co%20%22Chemical%20kinetics) (i.e., rate of decomposition). It is perhaps best, then, to differentiate between the terms thermodynamically stable and kinetically stable by referring to the former as "inert." Contrarily, a kinetically unstable substance is said to be "labile." It is generally recognized that certain groups like nitro (–NO2), [nitrate](http://en.wikipedia.org/wiki/Nitrate%22%20%5Co%20%22Nitrate) (–ONO2), and [azide](http://en.wikipedia.org/wiki/Azide%22%20%5Co%20%22Azide) (–N3), are intrinsically labile. Kinetically, there exists a low activation barrier to the decomposition reaction. Consequently, these compounds exhibit high sensitivity to flame or mechanical shock. The chemical bonding in these compounds is characterized as predominantly covalent and thus they are not thermodynamically stabilized by high ionic-lattice energy. Furthermore, they generally have positive enthalpies of formation and there is little mechanistic hindrance to internal molecular rearrangement to yield the more thermodynamically stable (more strongly bonded) decomposition products. For example, in [lead azide](http://en.wikipedia.org/wiki/Lead_azide%22%20%5Co%20%22Lead%20azide), Pb(N3)2, the nitrogen atoms are already bonded to one another, so decomposition into Pb and N2 is relatively easy. The rate of decomposition of explosives increases at higher temperatures. All standard military explosives may be considered to have a high degree of stability at temperatures from –10 to +35 °C, but each has a high temperature at which its rate of [decomposition](http://en.wikipedia.org/wiki/Thermal_decomposition%22%20%5Co%20%22Thermal%20decomposition) rapidly accelerates and stability is reduced. As a rule of thumb, most explosives become dangerously unstable at temperatures above 70 °C. When exposed to the [ultraviolet](http://en.wikipedia.org/wiki/Ultraviolet%22%20%5Co%20%22Ultraviolet) rays of sunlight, many explosive compounds containing [nitrogen](http://en.wikipedia.org/wiki/Nitrogen%22%20%5Co%20%22Nitrogen) groups rapidly decompose, affecting their stability. [Electrostatic](http://en.wikipedia.org/wiki/Electrostatic_discharge%22%20%5Co%20%22Electrostatic%20discharge) or [spark](http://en.wikipedia.org/wiki/Electric_spark%22%20%5Co%20%22Electric%20spark) sensitivity to initiation is common in a number of explosives. Static or other electrical discharge may be sufficient to cause a reaction, even detonation, under some circumstances. As a result, safe handling of explosives and [pyrotechnics](http://en.wikipedia.org/wiki/Pyrotechnics%22%20%5Co%20%22Pyrotechnics) usually requires proper [electrical grounding](http://en.wikipedia.org/wiki/Ground_%28electricity%29%22%20%5Co%20%22Ground%20%28electricity%29) of the operator.

**Fireworks**

 Fireworks are a class of [explosive](http://en.wikipedia.org/wiki/Explosive_material%22%20%5Co%20%22Explosive%20material) [pyrotechnic](http://en.wikipedia.org/wiki/Pyrotechnics%22%20%5Co%20%22Pyrotechnics) devices used for aesthetic, cultural, and religious purposes. The most common use of a firework is as part of a firework display. A firework event (also called a fireworks show or [pyrotechnics](http://en.wikipedia.org/wiki/Pyrotechnics%22%20%5Co%20%22Pyrotechnics)) is a display of the effects produced by firework devices. Firework competitions are also regularly held at a number of places. Fireworks take many forms to produce the four primary effects: noise, light, smoke and floating materials ([confetti](http://en.wikipedia.org/wiki/Confetti%22%20%5Co%20%22Confetti) for example). They may be designed to burn with flames and sparks of many colors, typically [red](http://en.wikipedia.org/wiki/Red%22%20%5Co%20%22Red), [orange](http://en.wikipedia.org/wiki/Orange_%28colour%29%22%20%5Co%20%22Orange%20%28colour%29), [yellow](http://en.wikipedia.org/wiki/Yellow%22%20%5Co%20%22Yellow), [green](http://en.wikipedia.org/wiki/Green%22%20%5Co%20%22Green), [blue](http://en.wikipedia.org/wiki/Blue%22%20%5Co%20%22Blue), [purple](http://en.wikipedia.org/wiki/Purple%22%20%5Co%20%22Purple), and [silver](http://en.wikipedia.org/wiki/Silver%22%20%5Co%20%22Silver). Displays are common throughout the world and are the focal point of many cultural and religious [celebrations](http://en.wikipedia.org/wiki/Celebration_%28party%29%22%20%5Co%20%22Celebration%20%28party%29). The earliest documentation of fireworks dates back to 7th century China, where they were invented. The fireworks were used to accompany many festivities. It is a part of the culture of China and had its origin there; eventually it spread to other cultures and societies. Important events and festivities such as the [Spring Festival](http://en.wikipedia.org/wiki/Chinese_New_Year%22%20%5Co%20%22Chinese%20New%20Year) (Chinese New Year) and the [Mid-Autumn Festival](http://en.wikipedia.org/wiki/Mid-Autumn_Festival%22%20%5Co%20%22Mid-Autumn%20Festival) were and still are times when fireworks are guaranteed sights. China is the largest manufacturer and exporter of fireworks in the world. Fireworks are generally classified as to where they perform, either as a ground or aerial firework. In the latter case they may provide their own [propulsion](http://en.wikipedia.org/wiki/Air_propulsion%22%20%5Co%20%22Air%20propulsion) ([skyrocket](http://en.wikipedia.org/wiki/Skyrocket%22%20%5Co%20%22Skyrocket)) or be shot into the air by a [mortar](http://en.wikipedia.org/wiki/Mortar_%28weapon%29%22%20%5Co%20%22Mortar%20%28weapon%29) ([aerial shell](http://en.wikipedia.org/wiki/Aerial_shell%22%20%5Co%20%22Aerial%20shell)). The most common feature of fireworks is a paper or [pasteboard](http://en.wikipedia.org/wiki/Card_stock%22%20%5Co%20%22Card%20stock) tube or casing filled with the combustible material, often [pyrotechnic stars](http://en.wikipedia.org/wiki/Pyrotechnic_stars%22%20%5Co%20%22Pyrotechnic%20stars). A number of these tubes or cases are often combined so as to make, when kindled, a great variety of sparkling shapes, often variously colored. The skyrocket is a common form of firework, although the first skyrockets were used in war. Such [rocket](http://en.wikipedia.org/wiki/Rocket%22%20%5Co%20%22Rocket) technology has also been used for the [delivery of mail by rocket](http://en.wikipedia.org/wiki/Rocket_mail%22%20%5Co%20%22Rocket%20mail) and is used as propulsion for most [model rockets](http://en.wikipedia.org/wiki/Model_rocket%22%20%5Co%20%22Model%20rocket). The aerial shell is the backbone of today's commercial aerial display. A smaller version for consumer use is known as the festival ball in the United States. Ground fireworks, although less popular than aerial ones, create a stunning exhibition. These types of fireworks can produce various shapes, such as simple rotating circles, stars and 3D globes.

 **Gasoline**

 Gasoline or petrol is a transparent, [petroleum](http://en.wikipedia.org/wiki/Petroleum%22%20%5Co%20%22Petroleum)-derived oil that is used primarily as a fuel in [internal combustion engines](http://en.wikipedia.org/wiki/Internal_combustion_engine%22%20%5Co%20%22Internal%20combustion%20engine). It consists mostly of [organic compounds](http://en.wikipedia.org/wiki/Organic_compound%22%20%5Co%20%22Organic%20compound) obtained by the [fractional distillation](http://en.wikipedia.org/wiki/Fractional_distillation%22%20%5Co%20%22Fractional%20distillation) of petroleum, enhanced with a variety of additives. Some gasolines also contain [ethanol](http://en.wikipedia.org/wiki/Ethanol%22%20%5Co%20%22Ethanol) as an [alternative fuel](http://en.wikipedia.org/wiki/Alternative_fuel%22%20%5Co%20%22Alternative%20fuel). In North America, the term *gasoline* is often shortened in colloquial usage to *gas*, while *petrol* is the common name in the UK, Republic of Ireland, Australia and in most of the other [Commonwealth](http://en.wikipedia.org/wiki/Commonwealth_of_Nations%22%20%5Co%20%22Commonwealth%20of%20Nations) countries. Under normal conditions, its physical state is a liquid, unlike [liquefied petroleum gas](http://en.wikipedia.org/wiki/Liquefied_petroleum_gas%22%20%5Co%20%22Liquefied%20petroleum%20gas) or [natural gas](http://en.wikipedia.org/wiki/Natural_gas%22%20%5Co%20%22Natural%20gas). Gasoline is more [volatile](http://en.wikipedia.org/wiki/Volatility_%28chemistry%29%22%20%5Co%20%22Volatility%20%28chemistry%29) than [diesel](http://en.wikipedia.org/wiki/Diesel_fuel%22%20%5Co%20%22Diesel%20fuel) oil, [Jet-A](http://en.wikipedia.org/wiki/Jet-A%22%20%5Co%20%22Jet-A), or [kerosene](http://en.wikipedia.org/wiki/Kerosene%22%20%5Co%20%22Kerosene), not only because of the base constituents, but also because of [additives](http://en.wikipedia.org/wiki/Gasoline_additive%22%20%5Co%20%22Gasoline%20additive). Volatility is often controlled by blending with [butane](http://en.wikipedia.org/wiki/Butane%22%20%5Co%20%22Butane), which boils at −0.5 °C. The volatility of gasoline is measured by the [Reid vapor pressure](http://en.wikipedia.org/wiki/Reid_vapor_pressure%22%20%5Co%20%22Reid%20vapor%20pressure)

(RVP) test. This volatility rises with an increase in the ambient temperature. In hot weather, gasoline is blended with components of higher [molecular weight](http://en.wikipedia.org/wiki/Molecular_weight%22%20%5Co%20%22Molecular%20weight) and this controls the tendency to greater volatility. In colder weather however, too little volatility can result in difficulty in starting an engine.

 In hot weather, excessive volatility can cause *[vapor lock](http://en.wikipedia.org/wiki/Vapor_lock%22%20%5Co%20%22Vapor%20lock)*, because the suction of the fuel pump has reduced the pressure in the fuel line to below the vapor pressure of the liquid fuel. This causes the column of fuel in the line to separate, producing a bubble of vapor that blocks the flow of the liquid, rendering the pump ineffective and starving the engine of fuel. This effect mainly occurs with camshaft-driven (engine mounted) fuel pumps. Vehicles with [fuel injection](http://en.wikipedia.org/wiki/Fuel_injection%22%20%5Co%20%22Fuel%20injection) require that the fuel be pressurized within the line therefore an electric pump is used, typically located in the fuel tank. Vapor lock is rarely a problem in a vehicle with fuel injection.

 In the US, volatility is regulated to reduce the emission of unburned hydrocarbons by the use of so-called reformulated gasoline that is less prone to evaporation. In Australia, summer gasoline volatility limits are set by state governments and vary among states. Most countries simply have summer, winter, and perhaps intermediate fuel formulations.

 Volatility standards may be relaxed (allowing more gasoline components into the atmosphere) during gasoline shortages. Modern automobiles are also equipped with an evaporative emissions control system, which collects evaporated fuel from the fuel tank in a charcoal-filled canister while the engine is stopped, and then releases the collected vapors to the engine for consumption when the engine is running (usually after it has reached normal [operating temperature](http://en.wikipedia.org/wiki/Operating_temperature%22%20%5Co%20%22Operating%20temperature)). The evaporative emissions control system also includes a sealed gas cap to prevent vapors from escaping via the fuel filler tube.

**Catalytic reforming**

 Catalytic reforming is a chemical process used to convert [petroleum refinery](http://en.wikipedia.org/wiki/Petroleum_refinery%22%20%5Co%20%22Petroleum%20refinery) [naphthas](http://en.wikipedia.org/wiki/Petroleum_naphtha%22%20%5Co%20%22Petroleum%20naphtha), typically having low [octane ratings](http://en.wikipedia.org/wiki/Octane_rating%22%20%5Co%20%22Octane%20rating), into high-octane liquid products called reformates which are components of high-octane [gasoline](http://en.wikipedia.org/wiki/Gasoline%22%20%5Co%20%22Gasoline) (also known as high-octane petrol). Basically, the process re-arranges or re-structures the [hydrocarbon](http://en.wikipedia.org/wiki/Hydrocarbon%22%20%5Co%20%22Hydrocarbon) [molecules](http://en.wikipedia.org/wiki/Molecules%22%20%5Co%20%22Molecules) in the naphtha feedstocks as well as breaking some of the molecules into smaller molecules. The overall effect is that the reformate contains hydrocarbons with more complex molecular shapes having higher octane values than the hydrocarbons in the naphtha feedstock. In so doing, the process separates [hydrogen](http://en.wikipedia.org/wiki/Hydrogen%22%20%5Co%20%22Hydrogen) [atoms](http://en.wikipedia.org/wiki/Atoms%22%20%5Co%20%22Atoms) from the hydrocarbon molecules and produces very significant amounts of hydrogen gas for use in a number of the other processes involved in a modern petroleum refinery. Other byproducts are small amounts of [methane](http://en.wikipedia.org/wiki/Methane%22%20%5Co%20%22Methane), [ethane](http://en.wikipedia.org/wiki/Ethane%22%20%5Co%20%22Ethane), [propane](http://en.wikipedia.org/wiki/Propane%22%20%5Co%20%22Propane), and [butanes](http://en.wikipedia.org/wiki/Butanes%22%20%5Co%20%22Butanes). This process is quite different from and not to be confused with the catalytic [steam reforming](http://en.wikipedia.org/wiki/Steam_reforming%22%20%5Co%20%22Steam%20reforming) process used industrially to produce various products such as [hydrogen](http://en.wikipedia.org/wiki/Hydrogen%22%20%5Co%20%22Hydrogen), [ammonia](http://en.wikipedia.org/wiki/Ammonia%22%20%5Co%20%22Ammonia), and [methanol](http://en.wikipedia.org/wiki/Methanol%22%20%5Co%20%22Methanol) from [natural gas](http://en.wikipedia.org/wiki/Natural_gas%22%20%5Co%20%22Natural%20gas), naphtha or other petroleum-derived feedstocks. Nor is this process to be confused with various other catalytic reforming processes that use methanol or [biomass-derived](http://en.wikipedia.org/wiki/Biomass%22%20%5Co%20%22Biomass) feedstocks to produce hydrogen for [fuel cells](http://en.wikipedia.org/wiki/Fuel_cells%22%20%5Co%20%22Fuel%20cells) or other uses. In the 1940s, Vladimir Haensel, a research chemist working for [Universal Oil Products](http://en.wikipedia.org/wiki/Universal_Oil_Products%22%20%5Co%20%22Universal%20Oil%20Products) (UOP), developed a [catalytic](http://en.wikipedia.org/wiki/Catalytic%22%20%5Co%20%22Catalytic) reforming process using a [catalyst](http://en.wikipedia.org/wiki/Catalyst%22%20%5Co%20%22Catalyst) containing [platinum](http://en.wikipedia.org/wiki/Platinum%22%20%5Co%20%22Platinum). Haensel's process was subsequently commercialized by UOP in 1949 for producing a high octane gasoline from low octane naphthas and the UOP process become known as the Platforming process. The first Platforming unit was built in 1949 at the refinery of the Old Dutch Refining Company in [Muskegon](http://en.wikipedia.org/wiki/Muskegon%22%20%5Co%20%22Muskegon), [Michigan](http://en.wikipedia.org/wiki/Michigan%22%20%5Co%20%22Michigan).In the years since then, many other versions of the process have been developed by some of the major oil companies and other organizations. Today, the large majority of gasoline produced worldwide is derived from the catalytic reforming process.

**Oil wells**

 The first stage in the construction of a well is the drill operation, which almost always involves rotary drilling. A derrick or a drilling mast is used to support the hoisting gear for raising and lowering the drilling equipment and to support the drilling string which consists of the rotating drill pipes. The length of steel pipe transmitting torque and vertical pressure to the drilling bit are also known as "rods" and those convey the drilling fluid to the bit. Drilling fluid or mud which is often a suspension of fine clayis used to cool the bit and to flush out cuttings, to support the wall of the hole and to seal porous rock thus preventing leakage of gas, oil or water. Commonly, the first 100 m or so of the hole, which is 450-500 mm in diameter is cased with steel pipe and the hole proper may be 200-300 mm in diameter. The top of the hole is fitted with valves to control the flow of mud and later the petroleum gases. Oil wells range in depth from 2,000 to 10,000 m. The passage of oil depends on the viscosity of the fluid and the permeability of the porous stratum but most importantly on driving pressure. This can be due either to gas, as in a gas-cap reservoir, or to water as in a water-drive reservoir. At the surface gas often comes out of solution in the oil and helps to lift the oil. This is often enhanced by passing gas down between the tubing and casing to promote the "air-lift" effect. The production from each well passes to a central gathering station where gas is separated and solids are removed by either settling or centrifuging.

The gas separation is purely mechanical at this stage. The separated crude oil and gas are now ready for further processing. Wells often must be treated to improve the recovery from a reservoir.

 **Oil field**

 The term "oil field" refers to a region with an abundance of [oil wells](http://en.wikipedia.org/wiki/Oil_well%22%20%5Co%20%22Oil%20well) extracting [petroleum](http://en.wikipedia.org/wiki/Petroleum%22%20%5Co%20%22Petroleum) (crude oil) from below ground. Because the [oil reservoirs](http://en.wikipedia.org/wiki/Oil_reservoir%22%20%5Co%20%22Oil%20reservoir) typically extend over a large area, possibly several hundred kilometers across, full exploitation entails multiple wells scattered across the area. In addition, there may be exploratory wells probing the edges, pipelines to transport the oil elsewhere, and support facilities.

Because an oil field may be remote from civilization, establishing a field is often an extremely complicated exercise in [logistics](http://en.wikipedia.org/wiki/Logistics%22%20%5Co%20%22Logistics). For instance, workers have to work there for months or years. In turn, housing and equipment require electricity and water. Pipelines in cold areas may need to be heated. The excess of [natural gas](http://en.wikipedia.org/wiki/Natural_gas%22%20%5Co%20%22Natural%20gas) may be [burned off](http://en.wikipedia.org/wiki/Gas_flare%22%20%5Co%20%22Gas%20flare) if there is no way to make use of it, requiring a furnace, stacks, and pipes to carry it from well to furnace. Thus, the typical oil field resembles a small, self-contained town in the midst of a landscape dotted with [drilling rigs](http://en.wikipedia.org/wiki/Drilling_rig%22%20%5Co%20%22Drilling%20rig) and/or the pump jacks known as "[nodding donkeys](http://en.wikipedia.org/wiki/Nodding_donkey%22%20%5Co%20%22Nodding%20donkey)" because of their bobbing arm. Several companies, such as [BJ Services](http://en.wikipedia.org/wiki/BJ_Services%22%20%5Co%20%22BJ%20Services), [Bechtel](http://en.wikipedia.org/wiki/Bechtel_Corporation%22%20%5Co%20%22Bechtel%20Corporation), [Esso](http://en.wikipedia.org/wiki/Esso%22%20%5Co%20%22Esso), [Schlumberger Limited](http://en.wikipedia.org/wiki/Schlumberger_Limited%22%20%5Co%20%22Schlumberger%20Limited), [Baker Hughes](http://en.wikipedia.org/wiki/Baker_Hughes%22%20%5Co%20%22Baker%20Hughes) and [Halliburton](http://en.wikipedia.org/wiki/Halliburton%22%20%5Co%20%22Halliburton), have organizations that specialize in the large-scale construction of the [infrastructure](http://en.wikipedia.org/wiki/Infrastructure%22%20%5Co%20%22Infrastructure) and providing specialized services required to operate a field profitably.

 More than 40,000 oil fields are scattered around the globe, on land and offshore. The largest are the [Ghawar Field](http://en.wikipedia.org/wiki/Ghawar_Field%22%20%5Co%20%22Ghawar%20Field) in [Saudi Arabia](http://en.wikipedia.org/wiki/Saudi_Arabia%22%20%5Co%20%22Saudi%20Arabia) and the [Burgan Field](http://en.wikipedia.org/wiki/Burgan_Field%22%20%5Co%20%22Burgan%20Field) in [Kuwait](http://en.wikipedia.org/wiki/Kuwait%22%20%5Co%20%22Kuwait), with more than 60 [billion](http://en.wikipedia.org/wiki/1000000000_%28number%29%22%20%5Co%20%221000000000%20%28number%29) [barrels](http://en.wikipedia.org/wiki/Barrel_%28unit%29%22%20%5Co%20%22Barrel%20%28unit%29) (9.5×109 m3) . Most oil fields are much smaller.

**General characteristic of oil and gas**

Both crude oil and natural gas are mixtures of molecules formed by carbon and hydrogen atoms. There are many different types of crude oils and natural gases, some more valuable than others. Heavy crude oils are very thick and viscous and are difficult or impossible to produce, whereas light crude oils are very fluid and relatively easy to produce. Less valuable are sour crude oils that contain sulfur and sour natural gasses that contain hydrogen sulfide. Some natural gases that burn with more heat than others, contain natural gas liquids and gasoline, and are more valuable. In order to have a commercial deposit of gas or oil, three geological conditions must have been met. First, there must be a source rock in the subsurface of that area that generated the gas or oil at some time in the geological past. Second, there must be a separate, subsurface reservoir rock to hold the gas or oil. Third, there must be a trap on the reservoir rock to concentrate the gas or oil into commercial quantities.The uppermost crust of the earth in oil- and gas-producing areas is composed of sedimentary rock layers. Sedimentary rocks are the source and reservoir rocks for gas and oil. These rocks are called sedimentary rocks because they are composed of sediments. Sediments are 1) particles such as sand grains that were formed by the breakdown of pre-existing rocks and, 2) seashells, or 3) salt that precipitated from of water. The sedimentary rocks that make up the earth’s crust are millions and sometimes billions of years old. During the vast expanse of geological time, sea level has not been constant. Many times in the past, the seas have risen to cover the land and then fallen to expose the land. During these times, sediments were deposited. These sediments are relatively simple materials such as sands deposited along beaches, mud on the sea bottom, and beds of seashells. These ancient sediments, piled layer upon layer, form the sedimentary rocks that are drilled to find and produce oil and gas.

**Generation of hydrocarbons**

The source of gas and oil is the organic matter that is buried and preserved in the ancient sedimentary rocks. These rocks contain not only inorganic particles such as sand grains and mud, but also dead plant and animal material. The most common organic-rich sedimentary rock (the source rock for most of the gas and oil) is black shale. It was deposited as organic-rich mud on an ancient ocean bottom. In the subsurface, temperature is the most important factor in turning organic matter into oil. As the source rock is covered with more sediments and buried deeper in the earth, it becomes hotter and hotter. The minimum temperature for the formation of oil, about 150°F (65°C), occurs at a depth of about 7000 ft (2130 m) below the surface. Oil is generated from there and down to about 300°F (150°C) at about 18,000 fit (5500 m). The reactions that change or-ganic matter into oil are complex and take a long time. If the source rock is buried deeper where the temperatures are above 300°F (150°C), the remaining organic matter will generate natural gas.Gas and oil are relatively light in density compared to water that also occurs in the subsurface sedimentary rocks. After oil and gas have been generated, they rise due to buoyancy through fractures in the subsurface rocks. The rising gas and oil can intersect a layer of reservoir rock. A reservoir rock is a sedimentary rock that contains billions of tiny spaces called pores. A common sedimentary rock is sandstone composed of sand grains similar to the sand grains on a beach or in a river channel. Sand grains are like spheres, and there is no way the grains will fit together perfectly. There are pore spaces between the sand grains on a beach and in a sandstone rock. Limestone, another common sedimentary rock, is deposited as shell beds or reefs, and there are pores between the shells and corals.

**Sodium**

 Sodium is a chemical element with symbol Na (from Latin: natrium) and atomic number 11. It is a soft, silvery-white, highly reactive metal and is a member of the alkali metals; its only stable isotope is 23Na. The free metal does not occur in nature; it was first isolated by Humphry Davy in 1807 by the electrolysis of sodium hydroxide. Sodium is the sixth most abundant element in the Earth's crust, and exists in numerous minerals such as feldspars, sodalite and rock salt. Many salts of sodium are highly water-soluble.

 Many sodium compounds are useful. Sodium hydroxide is used for soapmaking, and sodium chloride is used as a deicing agent and a nutrient. Sodium is an essential element for all animals and plants. In animals, sodium ions are used against potassium ions to build up charges on cell membranes, allowing transmission of nerve impulses when the charge is dissipated.

 Sodium at standard temperature and pressure is a soft metal that can be readily cut with a knife and is a good conductor of electricity. Sodium has a bright, silvery luster that rapidly tarnishes, forming a white coating of sodium hydroxide and sodium carbonate. These properties change at elevated pressures. All of these allotropes are insulators.

 When sodium or its compounds are introduced into a flame, they turn it yellow, because the excited 3s electrons of sodium emit a photon when they fall from 3p to 3s; the wavelength of this photon corresponds to the D line at 589.3 nm. Spin-orbit interactions involving the electron in the 3p orbital split the D line into two; hyperfine structures involving both orbitals cause many lines.

 Sodium is generally less reactive than potassium and more reactive than lithium. Like all the alkali metals, it reacts exothermically with water; this reaction produces caustic sodium hydroxide and flammable hydrogen gas. The extraction of sodium metal from its compounds uses a significant amount of energy.

**Liquids**

 Liquid is one of the three primary [states of matter](http://en.wikipedia.org/wiki/State_of_matter%22%20%5Co%20%22State%20of%20matter). The other states are [solid](http://en.wikipedia.org/wiki/Solid%22%20%5Co%20%22Solid) and [gas](http://en.wikipedia.org/wiki/Gas%22%20%5Co%20%22Gas). The [molecules](http://en.wikipedia.org/wiki/Molecule%22%20%5Co%20%22Molecule) in a liquid have a big freedom to move. A liquid can flow, take the shape of a container. A liquid not always mixes easily with another liquid. A liquid not always fills every space in the container. A liquid doesn’t compress significantly. It compresses only under very high pressures. These properties make a liquid suitable for applications such as [hydraulics](http://en.wikipedia.org/wiki/Hydraulics%22%20%5Co%20%22Hydraulics).

 Liquid particles are bound firmly. They are able to move around one another freely. When a liquid reaches its [boiling point](http://en.wikipedia.org/wiki/Boiling_point%22%20%5Co%20%22Boiling%20point), the cohesive forces that bind the molecules closely together, break, and the liquid changes to its gaseous state. If the temperature decreases, the distances between the molecules become smaller. When the liquid reaches its [freezing point](http://en.wikipedia.org/wiki/Melting_point%22%20%5Co%20%22Melting%20point) the molecules usually lock into a very specific order, called crystallizing, and the bonds between them become more rigid. It changes the liquid into its solid state if [supercooling](http://en.wikipedia.org/wiki/Supercooling%22%20%5Co%20%22Supercooling) doesn’t occur.

 Only two [elements](http://en.wikipedia.org/wiki/Chemical_element%22%20%5Co%20%22Chemical%20element) are liquid at [standard conditions for temperature and pressure](http://en.wikipedia.org/wiki/Standard_conditions_for_temperature_and_pressure%22%20%5Co%20%22Standard%20conditions%20for%20temperature%20and%20pressure): [mercury](http://en.wikipedia.org/wiki/Mercury_%28element%29%22%20%5Co%20%22Mercury%20%28element%29) and [bromine](http://en.wikipedia.org/wiki/Bromine%22%20%5Co%20%22Bromine). Four more elements have melting points slightly above [room temperature](http://en.wikipedia.org/wiki/Room_temperature%22%20%5Co%20%22Room%20temperature): [francium](http://en.wikipedia.org/wiki/Francium%22%20%5Co%20%22Francium), [cesium](http://en.wikipedia.org/wiki/Caesium%22%20%5Co%20%22Caesium), [gallium](http://en.wikipedia.org/wiki/Gallium%22%20%5Co%20%22Gallium) and [rubidium](http://en.wikipedia.org/wiki/Rubidium%22%20%5Co%20%22Rubidium). Metal alloys that are liquid at room temperature include [NaK](http://en.wikipedia.org/wiki/NaK%22%20%5Co%20%22NaK), a sodium-potassium metal alloy, [galinstan](http://en.wikipedia.org/wiki/Galinstan%22%20%5Co%20%22Galinstan), a fusible alloy, and some [amalgams](http://en.wikipedia.org/wiki/Amalgam_%28chemistry%29%22%20%5Co%20%22Amalgam%20%28chemistry%29) (alloys involving mercury).

 Pure substances which are liquid under normal conditions include [water](http://en.wikipedia.org/wiki/Water%22%20%5Co%20%22Water), [ethanol](http://en.wikipedia.org/wiki/Ethanol%22%20%5Co%20%22Ethanol) and many other organic solvents. Water is of a vital importance in chemistry and biology; it is necessary for the existence of [life](http://en.wikipedia.org/wiki/Life%22%20%5Co%20%22Life).

 Inorganic liquids include [water](http://en.wikipedia.org/wiki/Water%22%20%5Co%20%22Water), [inorganic nonaqueous solvents](http://en.wikipedia.org/wiki/Inorganic_nonaqueous_solvent%22%20%5Co%20%22Inorganic%20nonaqueous%20solvent) and many [acids](http://en.wikipedia.org/wiki/Acid%22%20%5Co%20%22Acid).

Important everyday liquids include aqueous [solutions](http://en.wikipedia.org/wiki/Solution%22%20%5Co%20%22Solution) like household [bleach](http://en.wikipedia.org/wiki/Bleach%22%20%5Co%20%22Bleach), other [mixtures](http://en.wikipedia.org/wiki/Mixture%22%20%5Co%20%22Mixture) of different substances such as [mineral oil](http://en.wikipedia.org/wiki/Mineral_oil%22%20%5Co%20%22Mineral%20oil) and [gasoline](http://en.wikipedia.org/wiki/Gasoline%22%20%5Co%20%22Gasoline), [emulsions](http://en.wikipedia.org/wiki/Emulsion%22%20%5Co%20%22Emulsion) like [mayonnaise](http://en.wikipedia.org/wiki/Mayonnaise%22%20%5Co%20%22Mayonnaise), [suspensions](http://en.wikipedia.org/wiki/Suspension_%28chemistry%29%22%20%5Co%20%22Suspension%20%28chemistry%29) like [blood](http://en.wikipedia.org/wiki/Blood%22%20%5Co%20%22Blood), and [colloids](http://en.wikipedia.org/wiki/Colloid%22%20%5Co%20%22Colloid) like [paint](http://en.wikipedia.org/wiki/Paint%22%20%5Co%20%22Paint) and [milk](http://en.wikipedia.org/wiki/Milk%22%20%5Co%20%22Milk).

 Many gases can be [liquefied](http://en.wikipedia.org/wiki/Liquefaction_of_gases%22%20%5Co%20%22Liquefaction%20of%20gases) by cooling, producing liquids such as [liquid oxygen](http://en.wikipedia.org/wiki/Liquid_oxygen%22%20%5Co%20%22Liquid%20oxygen), [liquid nitrogen](http://en.wikipedia.org/wiki/Liquid_nitrogen%22%20%5Co%20%22Liquid%20nitrogen), [liquid hydrogen](http://en.wikipedia.org/wiki/Liquid_hydrogen%22%20%5Co%20%22Liquid%20hydrogen) and [liquid helium](http://en.wikipedia.org/wiki/Liquid_helium%22%20%5Co%20%22Liquid%20helium). Not all gases can be liquefied at atmospheric pressure, for example [carbon dioxide](http://en.wikipedia.org/wiki/Carbon_dioxide%22%20%5Co%20%22Carbon%20dioxide) can only be liquefied at pressures above 5.1 [atm](http://en.wikipedia.org/wiki/Atmosphere_%28unit%29%22%20%5Co%20%22Atmosphere%20%28unit%29). Some materials cannot be classified within the classical three states of matter; they possess solid-like and liquid-like properties. Examples include [liquid crystals](http://en.wikipedia.org/wiki/Liquid_crystal%22%20%5Co%20%22Liquid%20crystal), used in LCD displays, and [biological membranes](http://en.wikipedia.org/wiki/Biological_membrane%22%20%5Co%20%22Biological%20membrane).

### **Calcium**

 Calcium is a soft silver-white metallic chemical element. It is malleable (can be rolled into a thin sheet) and ductile (can be drawn into wire), and can combine with many other metals to form alloys. At ordinary temperatures it is chemically stable in dry air, but is oxidized rapidly in moist air. Calcium is a strong reducing agent and is capable of converting most metallic oxides into their metals. It can combine with nonmetallic elements. At high temperatures, calcium is capable of absorbing oxygen, nitrogen and other gases.

 Calcium is essential to animal and plant life. It is the most abundant metallic element in animals, and is necessary to build strong bones, teeth and shells. It also occurs in body fluids and cells, where it plays a role in many activities, including muscle contraction, blood clotting, transmission of nerve impulses, and stimulation of many enzymatic reactions. Calcium is necessary for cell division in plants.

 Calcium is used mainly in preparing such metals as thorium and uranium that are difficult to obtain from their compounds. It is also used to remove nonmetallic impurities from various metals and alloys, and to remove oxygen and other gases from vacuum tubes. Calcium is alloyed with lead to make cable coverings.

 Calcium metal is usually obtained either by heating calcium oxide with aluminum in a vacuum or by electrolysis of molten calcium chloride.

 Calcium was discovered in 1808 by the British chemist Sir Humphry Davy. It is the fifth most abundant element in the earth’s crust, and is always found combined with other elements. Calcium occurs chiefly as carbonate, sulfate and phosphate in various rocks and minerals.

Most commercial calcium oxide is produced by heating limestone or dolomite.

 The symbol of calcium is Ca. Its atomic number is 20. Its atomic weight is 40.08. Calcium has melting point of 1,542 F. (839 C.).

 Calcium has boiling point of 2,703 F. (1,484 C.). Its specific gravity is 1.55. Calcium has six stable isotopes: Ca-40, Ca-42, Ca-43, Ca-44, Ca-46, and Ca-48. Calcium is an alkaline-earth metal; it belongs to Group IIA of the Periodic Table and has a valence of +2.

 **Cesium**

 Cesium is a silver-white metallic chemical element. Cesium is softer than talc. This element is ductile (can be drawn into wire), and it has a low melting point. Chemically, cesium is the most reactive of all metallic elements. It can combine with most nonmetallic elements. Cesium reacts violently with water to form cesium hydroxide and hydrogen. This reaction generates enough heat to ignite the hydrogen produced. When exposed to air, cesium ignites and burns rapidly. It is therefore stored in kerosene or in airtight containers. Cesium readily emits electrons when heated or deposed to light.

 Cesium was discovered in 1860 by the German scientists Robert W. Bunsen and Gustav Kirchhoff. This element is widely distributed in the earth’s crust, but in small quantities. The primary cesium ore is the mineral pollucite. Cesium

compounds are obtained from the ore by various metallurgical processes. The metal is usually obtained by heating cesium chloride or cesium bromide with calcium in a vacuum. Cesium is used to remove oxygen and other gases from vacuum tubes, to convert heat into electricity; in the manufacture of photoelectric cells, infrared lamps and spectrographic instruments. Cesium compounds are used in the manufacture of chemicals, mineral water, optical crystals and vacuum tubes. Cesium atoms vibrate so regularly that the rate is used in timekeeping as a standard for establishing the length of the second. The symbol of cesium is Cs. Its atomic number is 55.The atomic weight of cesium is 132.9054. Its melting point is 83.7 F. (28.7 C.). The boiling point of cesium is 1,252 F. (678 C.). Cesium has specific gravity of 1.87. Cesium has one stable isotope: Cs-133. Cesium is an alkali metal and belongs to Group I-A of the Periodic Table. It has a valence of +2.

### **Solubility in Water**

 Water has been referred to as the "universal solvent", and its widespread distribution on this planet and essential role in life make it the benchmark for discussions of solubility. Water dissolves many ionic salts thanks to its high dielectric constant and ability to solvate ions. The former reduces the attraction between oppositely charged ions and the latter stabilizes the ions by binding to them and delocalizing charge density. Many organic compounds, especially alkanes and other hydrocarbons, are nearly insoluble in water. Organic compounds that are water soluble, such as most of those listed in the above table, generally have hydrogen bond acceptor and donor groups. The least soluble of the listed compounds is diethyl ether, which can serve only as a hydrogen bond acceptor and is 75% hydrocarbon in nature. Even so, diethyl ether is about two hundred times more soluble in water than is pentane. The chief characteristic of water that influences these solubilities is the extensive hydrogen bonded association of its molecules with each other. This hydrogen bonded network is stabilized by the sum of all the hydrogen bond energies, and if nonpolar molecules such as hexane were inserted into the network they would destroy local structure without contributing any hydrogen bonds of their own. Of course, hexane molecules experience significant van der Waals attraction to neighboring molecules, but these attractive forces are much weaker than the hydrogen bond. Consequently, when hexane or other nonpolar compounds are mixed with water, the strong association forces of the water network exclude the nonpolar molecules, which must then exist in a separate phase. This is shown in the following illustration, and since hexane is less dense than water, the hexane phase floats on the water phase. It is important to remember this tendency of water to exclude nonpolar molecules and groups, since it is a factor in the structure and behavior of many complex molecular systems. A common nomenclature used to describe molecules and regions within molecules is hydrophilic for polar, hydrogen bonding moieties and hydrophobic for nonpolar species.

### **Intermolecular Forces and Physical Properties**

The attractive forces that exist between molecules are responsible for many of the bulk physical properties exhibited by substances. Some compounds are gases, some are liquids, and others are solids. The melting and boiling points of pure substances reflect these intermolecular forces, and are commonly used for identification. Of these two, the boiling point is considered the most representative measure of general intermolecular attractions. Thus, a melting point reflects the thermal energy needed to convert the highly ordered array of molecules in a crystal lattice to the randomness of a liquid. The distance between molecules in a crystal lattice is small and regular, with intermolecular forces serving to constrain the motion of the molecules more severely than in the liquid state. Molecular size is important, but shape is also critical, since individual molecules need to fit together cooperatively for the attractive lattice forces to be large. Spherically shaped molecules generally have relatively high melting points, which in some cases approach the boiling point, reflecting the fact that spheres can pack together more closely than other shapes. This structure or shape sensitivity is one of the reasons that melting points are widely used to identify specific compounds.
Boiling points, on the other hand, essentially reflect the kinetic energy needed to release a molecule from the cooperative attractions of the liquid state so that it becomes an unencumbered and relative independent gaseous state species. All atoms and molecules have a weak attraction for one another, known as van der Waals attraction. This attractive force has its origin in the electrostatic attraction of the electrons of one molecule or atom for the nuclei of another.
The following animation illustrates how close approach of two neon atoms may perturb their electron distributions in a manner that induces dipole attraction. The induced dipoles are transient, but are sufficient to permit liquefaction of neon at low temperature and high pressure. In general, larger molecules have higher boiling points than smaller molecules of the same kind, indicating that dispersion forces increase with mass, number of electrons, number of atoms or some combination thereof. The following table lists the boiling points of an assortment of elements and covalent compounds composed of molecules lacking a permanent dipole. The number of electrons in each species is noted in the first column, and the mass of each is given as a superscript number preceding the formula. Two of ten electron molecules are shown in the first row. Neon is heavier than methane, but it boils 84º lower. Methane is composed of five atoms, and the additional nuclei may provide greater opportunity for induced dipole formation as other molecules approach. The ease with which the electrons of a molecule, atom or ion are displaced by a neighboring charge is called polarizability, so we may conclude that methane is more polarizable than neon. In the second row, four eighteen electron molecules are listed. Most of their boiling points are higher than the ten electron compounds neon and methane, but fluorine is an exception, boiling 25º below methane. The remaining examples in the table conform to the correlation of boiling point with total electrons.
The anomalous behavior of fluorine may be attributed to its very high electronegativity. The fluorine nucleus exerts such a strong attraction for its electrons that they are much less polarizable than the electrons of most other atoms.

**Thermodynamic and Chemical Stability**

 An important distinction can now be made between thermodynamic stability and chemical stability. Thermodynamic stability refers to the potential energy of a compound, and is related to the bond energies of its constituent atoms. Chemical stability refers to a compound's resistance to chemical reaction with a variety of reagents, and is related to the activation energy barrier it presents to possible chemical change. A comparison of cyclohexene and benzene provides a good example of this distinction. Both these compounds add hydrogen in exothermic addition reactions that give cyclohexane as a common product. From heats of hydrogenation we find that cyclohexene has a potential energy (P.E.) roughly 28.6 kcal/mol higher than cyclohexane, whereas benzene is 48.9 kcal/mol above cyclohexane. This relationship is graphed on the right.
 We conclude from these measurements that both cyclohexene and benzene are thermodynamically less stable than cyclohexane, and that benzene is thermodynamically less stable than cyclohexene. We know, however, that the chemical reactivity of these unsaturated compounds does not reflect this stability order. Cyclohexene reacts rapidly with bromine, as well as with potassium permanganate and sulfuric acid, whereas benzene is relatively inert to all three reagents (in the absence of catalysts and/or heat). The chemical reactivity of benzene is therefore less than the reactivity of cyclohexene, and we may say that benzene is chemically more stable than cyclohexene - at least toward the reagents noted here. Just as a chain is no stronger than its weakest link, a molecule may be rendered chemically unstable by one weak bond. We see this in the chemical behavior of peroxides (R–O–O–R). The O–O bond is less than half as strong as a C–C bond, and peroxides are notoriously unstable, decomposing via alkoxy radicals (R–O·) on mild heating. The useful organization of organic reactions by functional groups is a further example of how a few susceptible bonds in a molecule can determine its general chemical reactivity.

### **Activation Energy**

### Since exothermic reactions are energetically (thermodynamically) favored, a careless thinker might conclude that all such reactions will proceed spontaneously to their products. Were this true, no life would exist on Earth, because the numerous carbon compounds that are present in and essential to all living organisms would spontaneously combust in the presence of oxygen to give carbon dioxide-a more stable carbon compound. The combustion of methane, for example, does not occur spontaneously, but requires an initiating energy in the form of a spark or flame. The flaw in this careless reasoning is that we have focused only on the initial (reactant) and final (product) states of reactions. To understand why some reactions occur readily (almost spontaneously), whereas other reactions are slow, even to the point of being unobservable, we need to consider the intermediate stages of reactions.

 Every reaction in which bonds are broken will have a high energy **transition state** that must be reached before products can form. In order for the reactants to reach this transition state, energy must be supplied and reactant molecules must orient themselves in a suitable fashion. The energy needed to raise the reactants to the transition state energy level is called the **activation energy, ΔE‡**. An example of a single-step exothermic reaction profile is shown on the left above, and a similar single-step profile for an endothermic reaction is in the center. The activation energy is drawn in red in each case, and the overall energy change (ΔE) is in green.
 The profile becomes more complex when a multi-step reaction path is described. An example of a two-step reaction proceeding by way of a high energy intermediate is shown on the right above. Here there are two transition states, each with its own activation energy. The overall activation energy is the difference in energy between the reactant state and the highest energy transition state. We see now why the rate of a reaction may not correlate with its overall energy change. In the exothermic diagram on the left, a significant activation energy must be provided to initiate the reaction. Since the reaction is strongly exothermic, it will probably generate enough heat to keep going as long as reactants remain. The endothermic reaction in the center has a similar activation energy, but this will have to be supplied continuously for the reaction to proceed to completion. What is the source of the activation energy that enables a chemical reaction to occur? Often it is heat, as noted above in reference to the flame or spark that initiates methane combustion. At room temperature, indeed at any temperature above absolute zero, the molecules of a compound have a total energy that is a combination of translational (kinetic) energy, internal vibrational and rotational energies, as well as electronic and nuclear energies. The temperature of a system is a measure of the average kinetic energy of all the atoms and molecules present in the system.

**Magnesium**

 Magnesium is a silvery, metallic element. It is very light, weighing only two-thirds as much as aluminum. Magnesium is an abundant element of the earth’s crustand is always found combined with other elements. Magnesium is malleable and has a relatively high tensile strength. It will dissolve in acids but is insoluble in water. When heated in air, filaments or particles of magnesium will burn readily, giving off an intense white light. Small amounts of magnesium are essential for plant and animal life.

 Magnesium is produced commercially from brines and seawater, and from dolomite and other minerals. Brines and seawater are treated with lime and hydrochloric acid to produce magnesium chloride. Pure magnesium is obtained from the chloride by electrolysis. Dolomite is treated by a silico-thermic process. The dolomite is vaporized in the presence of silicon. Crystals of pure magnesium are formed from the vapor. The United States is the leading producer of magnesium, usually accounting for about 40 per cent of the world’s output.

 Because of its light weight, magnesium is alloyed with other metals (primarily aluminum, zinc or manganese) for use in airplane parts, automobile parts, portable tools, luggage, and photographic equipment. Alloys of magnesium are easy to machine and take a good finish. Magnesium is used as a reducing agent in the refining of titanium, uranium, and other metals. Because magnesium burns brightly, it is used in flares, flashbulbs, and fireworks. Magnesium is also used in some dry-cell batteries and photoengraving.

 Among the important compounds of magnesium are its oxide (magnesia), its sulfate (epsom salts), its chloride and its carbonate (magnesite). Magnesium compounds are used in fertilizers, insulation, medicines and refractory materials. They are also used in textile processing and papermaking.

 Magnesium was first recognized as a separate metal element by the Scottish chemist Joseph Black in 1755. It was isolated by Sir Humphry Davy, an English chemist in 1808 and first obtained in a pure metallic form in 1831 by Antoine Bussy of France.

 The symbol of magnesium is Mg. It belongs to group 2 (formerly IIA) of the Periodic Table. Its atomic number is 12. The relative atomic mass of magnesium is24.305. Magnesium has relative density of 1.74. Its melting point is 648.8oC, its boiling point is 1090oC.

**Gold**

 Gold is a [chemical element](http://en.wikipedia.org/wiki/Chemical_element%22%20%5Co%20%22Chemical%20element) with the symbol Au and [atomic number](http://en.wikipedia.org/wiki/Atomic_number%22%20%5Co%20%22Atomic%20number) 79. It is a dense, soft, malleable [metal](http://en.wikipedia.org/wiki/Metal%22%20%5Co%20%22Metal). It has a bright yellow color and luster. It preserves its luster when it tarnishes in air or water. Chemically, gold is a [transition metal](http://en.wikipedia.org/wiki/Transition_metal%22%20%5Co%20%22Transition%20metal). It is one of the least reactive chemical elements. It is solid under standard conditions. The metal occurs often in free elemental form. Gold is not attacked by individual acids. But it can be dissolved by [aqua regia](http://en.wikipedia.org/wiki/Aqua_regia%22%20%5Co%20%22Aqua%20regia) (nitro-hydrochloric acid). It is named like that because it dissolves gold. Gold is also dissolved in alkaline solutions of [cyanide](http://en.wikipedia.org/wiki/Cyanide%22%20%5Co%20%22Cyanide). It is dissolved in [mercury](http://en.wikipedia.org/wiki/Mercury_%28element%29%22%20%5Co%20%22Mercury%20%28element%29) and forms [amalgam](http://en.wikipedia.org/wiki/Amalgam_%28chemistry%29%22%20%5Co%20%22Amalgam%20%28chemistry%29) alloys. It is insoluble in [nitric acid](http://en.wikipedia.org/wiki/Nitric_acid%22%20%5Co%20%22Nitric%20acid), which dissolves silver. Common [oxidation states](http://en.wikipedia.org/wiki/Oxidation_state%22%20%5Co%20%22Oxidation%20state) of gold include +1 and +3.

Gold is a good [conductor of heat](http://en.wikipedia.org/wiki/Conduction_%28heat%29%22%20%5Co%20%22Conduction%20%28heat%29) and [electricity](http://en.wikipedia.org/wiki/Electrical_conductor%22%20%5Co%20%22Electrical%20conductor). It reflects [infrared radiation](http://en.wikipedia.org/wiki/Infrared_radiation%22%20%5Co%20%22Infrared%20radiation). Chemically, it is influenced by [air](http://en.wikipedia.org/wiki/Earth%27s_atmosphere%22%20%5Co%20%22Earth%27s%20atmosphere), [moisture](http://en.wikipedia.org/wiki/Moisture%22%20%5Co%20%22Moisture) and most [corrosive](http://en.wikipedia.org/wiki/Corrosion%22%20%5Co%20%22Corrosion) [reagents](http://en.wikipedia.org/wiki/Reagent%22%20%5Co%20%22Reagent). It is well suited for use in the production of [coins](http://en.wikipedia.org/wiki/Coin%22%20%5Co%20%22Coin) and [jewelry](http://en.wikipedia.org/wiki/Jewelry%22%20%5Co%20%22Jewelry). It is also used as a protective coating on other metals. However, it is not chemically inert. Gold ions in solution are readily [reduced](http://en.wikipedia.org/wiki/Reduction_%28chemistry%29%22%20%5Co%20%22Reduction%20%28chemistry%29) and [precipitated](http://en.wikipedia.org/wiki/Precipitation_%28chemistry%29%22%20%5Co%20%22Precipitation%20%28chemistry%29). Gold has only one stable [isotope](http://en.wikipedia.org/wiki/Isotope%22%20%5Co%20%22Isotope), 197Au, which is also its only naturally occurring isotope. Gold has many industrial applications. For example, it is used in the connectors of the more expensive electronic cables, such as audio, video and [USB](http://en.wikipedia.org/wiki/USB%22%20%5Co%20%22USB) cables. Gold or alloys of gold and [palladium](http://en.wikipedia.org/wiki/Palladium%22%20%5Co%20%22Palladium) are applied as a conductive coating to biological specimens and other non-conducting materials. Gold produces a deep, intense red color when we use it as a coloring agent. Gold is a good reflector of [electromagnetic radiation](http://en.wikipedia.org/wiki/Electromagnetic_radiation%22%20%5Co%20%22Electromagnetic%20radiation). It is used for the protective coatings on many [satellites](http://en.wikipedia.org/wiki/Satellite%22%20%5Co%20%22Satellite). Gold is dissolved in the alkaline solutions of potassium or sodium [cyanide](http://en.wikipedia.org/wiki/Cyanide%22%20%5Co%20%22Cyanide) and forms the salt of gold cyanide. This technique is used in extracting metallic gold from ores in the [cyanide process](http://en.wikipedia.org/wiki/Cyanide_process%22%20%5Co%20%22Cyanide%20process). Gold cyanide is an [electrolyte](http://en.wikipedia.org/wiki/Electrolyte%22%20%5Co%20%22Electrolyte) which is used in [electroforming](http://en.wikipedia.org/wiki/Electroforming%22%20%5Co%20%22Electroforming). The solutions of gold chloride are used to make colloidal gold by reduction with [citrate](http://en.wikipedia.org/wiki/Citrate%22%20%5Co%20%22Citrate) or [ascorbate](http://en.wikipedia.org/wiki/Ascorbate%22%20%5Co%20%22Ascorbate) [ions](http://en.wikipedia.org/wiki/Ions%22%20%5Co%20%22Ions). Gold chloride and gold oxide are used to make red-colored glass, which, like [colloidal](http://en.wikipedia.org/wiki/Colloid%22%20%5Co%20%22Colloid) gold suspensions, contains spherical [gold nanoparticles](http://en.wikipedia.org/wiki/Gold_nanoparticle%22%20%5Co%20%22Gold%20nanoparticle).

**Tests**

**Participles**

1. This reaction involves the \_\_\_\_\_\_\_ temperature changes.
2. followed b) following c) follows d)follow
3. The values \_\_\_\_\_\_ have a little relevance to this problem.
4. obtained b)obtaining c)obtains d) obtains
5. The \_\_\_\_\_\_ admixtures were separated from the end product.
6. remains b) remain c)remaining d) remind
7. Cobalt is usually \_\_\_\_\_ for use.
8. alloy b) alloying c) to alloy d) alloyed
9. Iron is a very reactive metal \_\_\_\_\_\_\_with nonmetals.
10. combining b) combine c) combination d) combined
11. The compound \_\_\_\_ is readily oxidized.
12. formed b) formation c) forming d) forms
13. The solution of cobalt (II) nitrate \_\_\_\_\_at high temperatures is often converted into pink impure cobalt hydroxide.
14. boiled b) the boiling c) boiling d) boil
15. Nickel oxide \_\_\_\_ in the acid is less effective.
16. dissolving b) dissolves c) dissolves d) dissolved
17. This element has a very high \_\_\_\_\_\_ point.
18. melting b) melts c) melted d) to melt
19. This suggests that these compounds \_\_\_\_\_\_ from the isomeric oxides are not identical.
20. obtained b) obtaining c) obtains d) to obtain

Keys

1. b
2. a
3. c
4. d
5. a
6. a
7. c
8. d
9. a

 **Participle constructions and construction: under+noun**

1. Ammonia is an extremely soluble in water \_\_\_\_\_ basic solutions that contain solvated NH3 molecules.

1. gives b) gave c) to give d)giving

2. The product \_\_\_\_\_\_ chlorine has varied as a result of temperature rise.

 a) containing b) to contain c) content d)contained

3. When \_\_\_\_\_\_ to sunlight the peroxide is isomerized to the oxidoketone.

 a) exposed b) exposing c) expose d) to expose

4. At this temperature the material under \_\_\_\_ is fed.

 a) examining b) exam c) examination d) exams

5. The substance \_\_\_\_\_ with acids is nitrogen oxide.

 a) reacts b) reacting c) reacted d) to react

6. This reaction occurs \_\_\_\_\_ the very high pressure.

 a) under b) in c) on d) above

7. The temperature \_\_\_\_ 10 0C, water boiled quickly

 a) being b)was c) were d) to be

8. The experiments \_\_\_\_\_\_\_, we started new investigations.

 a) to carry out b)carries out c) having been carried out d)carries

9. Oxidations were carried out in 300 ml conical flasks \_\_\_\_\_ with special condenser heads.

 a) equipment b) having an equipment c) equips d)equipped

10. The reaction \_\_\_\_\_ study can be accompanied by resin formation.

 a) under b) in c) at d) on

Keys

1. d
2. a
3. a
4. C
5. b
6. a
7. a
8. c
9. d
10. a

**Gerund**

1. This is done by \_\_\_\_\_ two gas channels

1. employing b) employed c) to employ d) employs

2. \_\_\_\_ carbon vapours over the catalyst gives the moderate yield of mercaptan.

 a) passes b) to pass c) passing d)passed

3. This effect is a potentially attractive means of \_\_\_\_\_ flame.

 a) controlling b) control c) controls d) controlled

4. Instead of \_\_\_ chlorine they took bromine.

a) use b) uses c) the use d) using

5. The method is based on \_\_\_\_ an electroactive center.

 a) incorporating b) incorporates c) incorporated d) incorporate

6. They hinted at the possibility of \_\_\_\_ the coordinative properties of the interface

 a) modulate b) to modulate c) modulating d) modulated

7. \_\_\_\_ cytokines is a stage process

 a) obtaining b) to obtain c) was obtained d) to be obtained

8. The turbulent flow of gases produces \_\_\_\_\_.

 a) to cool b)cooled c) cooling d)cools

9. The same burette was used for \_\_\_\_ sample solutions.

 a) measurement b) measuring c) measures d)measured

10. Cerium is oxidized to the tetravalent state by \_\_\_\_ perchloric acid.

 a) boiling b) boils c) boil d) to boil

keys

1. a
2. c
3. a
4. d
5. a
6. c
7. a
8. c
9. b
10. a

**Present Simple, Past Simple and Future Simple**

1. The halobenzenes \_\_\_ a number of compounds.
2. form b)formed c) forms d) will form
3. Last time these reactions \_\_\_ at high temperatures.
4. taking place b) will take place c) took place d) takes
5. Tomorrow we \_\_\_ how to produce a diamond.
6. Will study b) studied c) studied d) study
7. Graphite usually \_\_\_ naturally.
8. occurs b) to occur c) occurring d) to occur
9. The molecule, C60, \_\_\_\_ after the US architect Richard Buckminster Fuller.
10. Was named b) is named c) names d) name
11. I think in the nearest future the level of carbon dioxide \_\_\_\_ in the atmosphere.
12. increase b) increases c) increased d) will increase
13. A neutral oxide \_\_\_\_ in air to give carbon dioxide.
14. Burning b) burnt c) burned d) burns
15. Last year we \_\_\_\_\_ a new combustion technique.
16. Develops b) developed c) development d) develop
17. We \_\_\_\_ the benzene structure analysis next week.
18. Will carry out b) carries out c) carry out d) carry
19. Carbonates usually \_\_\_\_ on heating.
20. decomposes b) decomposed c) decompose d) decomposition

Keys

1. a
2. c
3. a
4. a
5. a
6. d
7. d
8. b
9. a
10. c

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