**UNIT ONE: ATOM AND MATTER**

**Part I “STANDARD MODEL”**

“The creating element in the mind of man emerges in as mysterious a fashion as those elementary particles which leap into momentary existence in great cyclotrons, only to vanish again like infinitesimal ghosts”

Sir Arthur Eddington, 1928

LEAD-IN

1. **Discuss these questions with your partner.**

What is an atom?

What is smaller than an atom?

What happens if you split an atom?

VOCABULARY

**2. Match these words with their definitions.**

1. subatomic a part of an atom which has no charge
2. electron b two or more particles
3. neutron c smaller than an atom
4. molecule d part of an atom that has a negative charge
5. proton e a theory developed by physicists to explain the atom
6. quantum mechanics f part of an atom which has a positive charge
7. carbon g pulled together
8. attracted h a chemical element
9. universe i a chemical element that is lighter than air
10. helium j the whole cosmos

**3. Read and complete the text using the words below.**

STANDARD MODEL

1. All matter around us is made of elementary particles, the building blocks of matter. These particles occur in two basic types: quarks and leptons. Each group consists of six particles, which are related in pairs, or 1)… . The lightest and most stable particles make up the first generation, whereas the heavier and less stable particles belong to the second and third generations. All stable matter in the universe is made from particles that belong to the first generation, and heavier particles quickly decay to the next most stable level. The six quarks are paired in the three generations-the up quark and bottom (or beauty) quark; next come ‘strange’ and ‘charm’ quarks; finally, the ‘top and bottom’ quarks are the heaviest pair. Quarks also come in three different “colors”: red, blue and green. Just as electrons and protons carry “color charge”, which is 2)… when quarks change from one type to another. Color charge has nothing to do with the visible colors of light- it is just an arbitrary way of naming the quantum properties of quarks. Just as electric charges produce a force, so color charges (quarks) can exert forces on one another. Color force gets 3)… the further the quarks are apart, so they stick together as if held by an invisible elastic band. Because the color force field tie is so strong, quarks cannot exist on their own and must always be locked together in combinations that are color neutral overall (exhibiting no color charge).
2. The second class of particles, the leptons, are related to and include 4)… . Again there are three generations with increasing masses: electrons, muons and taus. 5)… are 200 times heavier than an electron and taus 3700 times. (A) Leptons all have single negative charge. (B) They also have an associated particle called a neutrino (electron,muon and tau-neutrino) that has no charge. (C) Neutrinos have almost no mass and do not interact much with anything . (D)They can travel right through the Earth without noticing, so are difficult to catch. All leptons have antiparticles.
3. Fundamental forces are mediated by the exchange of particles. There are four fundamental forces at work in universe: the strong force, the weak force, the electromagnetic force, the gravitation force. They work over different ranges and have different strengths. Gravity is the weakest but it has an infinite range. The electromagnetic force also has 7)… range but it is many times stronger than gravity. The weak and strong forces are effective only over a short range and dominate only at the level of 8)… particles. Despite its name, the weak force is much stronger than gravity but it is indeed the weakest of the other three. The strong force is the strongest of all four fundamental interactions.
4. Three of the fundamental forces result from the exchange of force-carrier particles, which belong to a broader group called 9)… . Particles of matter transfer discrete amounts of energy by exchanging bosons with each other. Each fundamental force has its own corresponding boson- the strong force is carried by the 10)… , the electromagnetic force is carried by the photon and the W and the Z bosons are responsible for the weak force.
5. The Standard model includes the electromagnetic, strong and weak forces and all their carrier particles, and explains well how these forces act on all of the matter particles. However, the most familiar force in our everyday lives, 11)… , is not part of the Standard model, as fitting gravity comfortably into this framework has proved to be a difficult challenge.
6. How do we know about these subatomic particles? Particle accelerators use giant magnets to accelerate particles to extremely high speeds and smash those particle beams either into a target or into another oppositely directed beam. At 12)… speeds, the particles break apart a little and the lightest generations of particles are released. Because mass means energy, you need a higher particle beam to release the heavier generations of particles.
7. 1\_\_ In the magnetic field, positive charged particles swerve one way and negative ones the other. 2\_\_ The particles produced in the atom smashers then need to be identified and particle physicists do this by photographing their 13)… as they pass through a magnetic field. 3\_\_ By mapping their characteristics in the detector, and comparing them with what they expect from their theories, particle physicists can tell what each particle is. 4\_\_ The mass of the particle also dictates how fast it shoots through the detector and how much its path is curved by the magnetic field. 5\_\_ So light particles barely curve and heavier particles may even spiral into loops.

|  |  |
| --- | --- |
| 1. tracks 2. electrons 3. muons 4. subatomic 5. stronger 6. modest | 1. negative 2. generations 3. bosons 4. conversed 5. gravity 6. infinite 7. gluons |

**4. Arrange the sentences of the last paragraph in the right order.**

**5. Read the text again and find the words that mean the same as the following definitions.**

1. a property of something that dictates its potential for change;
2. a fundamental force through which masses attract one another;
3. a means of transmitting a force at a distance;
4. light manifesting as a particle;
5. physical substance in general that everything in the world consists of;
6. a property that is equivalent to the number of atoms or amount of energy that something contains;
7. to be destroyed gradually by natural processes;
8. to move in continuous circles, going upwards or downwards;
9. a lift, pull or push, causing the motion of something to change;
10. a fundamental particle, three of which combine to make up protons and neutrons.

**6. In pairs, discuss and write definitions for the following terms from the text. Use a dictionary to help you.**

stable

charge

infinitesimal

dominate

discrete

magnet

release

beam

curve (n)

**7. Fill the gaps with the new words:**

***decay, boson, subatomic, mass, energy, muons, stable, magnet, curve, release, gravity***

**PART A**

1. The \_\_\_\_\_\_\_\_\_\_ of a substance doesn’t change with temperature or location in space.
2. The\_\_\_\_\_\_\_\_\_\_ of light is transformed directly into electricity in photocells.
3. Ernest Rutherford was the first to suggest that radioactivity was the result of atomic \_\_\_\_\_\_\_\_\_\_.
4. Although simple harmonic motion is predictable and \_\_\_\_\_\_\_\_\_\_ , adding even small extra forces can destabilize it and may precipitate catastrophe.
5. Not all\_\_\_\_\_\_\_\_\_\_ particles are charged, however.
6. Hold two\_\_\_\_\_\_\_\_\_\_ close to one another, you can feel them repel.
7. Every body has a centre of\_\_\_\_\_\_\_\_\_\_.
8. \_\_\_\_\_\_\_\_\_\_ are much heavier than electrons but lighter than taus.
9. The ball\_\_\_\_\_\_\_\_\_\_ through the air.
10. Intense heat is\_\_\_\_\_\_\_\_\_\_ in the reaction.
11. The Higgs\_\_\_\_\_\_\_\_\_\_ is called ‘God particle’.

**PART B**

***charge, infinitesimal, dominate, discrete, beam, spiral, track***

1. If the gap is small compared with the distance between the waves then the rounded edges \_\_\_\_\_\_\_\_\_\_ the pattern and the transmitted wave may look almost semi-circular.
2. Using together Heiesenberg’s matrix mechanics and Schrodinger’s wave equation was fundamentally difficult because one was\_\_\_\_\_\_\_\_\_\_ and the other continuous.
3. Turn the quarks into antiquarks by flipping their\_\_\_\_\_\_\_\_\_\_, and you’ve made an antineutron.
4. On some surfaces the \_\_\_\_\_\_\_\_\_\_ of the particles became unstable, and they fell off the edge.
5. During the experiment the\_\_\_\_\_\_\_\_\_\_ traces of poison were found.
6. The time the \_\_\_\_\_\_\_\_\_\_ takes to travel to the Moon and back can be used to calculate the distance to the Moon.
7. The plane\_\_\_\_\_\_\_\_\_\_ down the ground.

**8. Look at the four lettered spaces in the text (A),(B),(C),(D) that indicate where the following sentence can be added to the passage.** **Where would this sentence best fit?**

*The biggest difference between leptons and quarks is that leptons don’t have color charges, and therefore aren’t affected by the strong force.*

**9. Which of the sentences below expresses the summary of the text:**

* Standard Model is a quite table of all elementary particles;
* Standard Model is an attempt to create a unified theory;
* Standard Model is a theoretical structure of interactions of all elementary particles.

**10. Choose the phrase which could replace parts of these phrases.**

1. Color charge has nothing to do
2. Isn’t connected with the light spectra;
3. Doesn’t have anything in common with colors of light;
4. Isn’t carried by light;
5. Fundamental forces are mediated
6. are carried;
7. are suppressed;
8. are balanced;
9. fitting gravity comfortably into this framework
10. including gravity into Standard Model;
11. adding gravity to Standard Model;
12. making gravity suitable for the requirements of Standard Model.

**11. For each set find one word mentioned in the text that will fit all sentences.**

A.

1. The anti-electron has its own name, position. It’s a\_\_\_\_\_\_\_\_\_\_\_of common knowledge.
2. \_\_\_\_\_\_\_\_\_\_\_is made of atoms and atoms are made of electrons and quarks exchanging photons and gluons.
3. No\_\_\_\_\_\_\_\_\_\_\_ when particle and antiparticle meet, their motion in complex time cancels out and they combine into photon which has zero movement in time.

B.

a) The fusion process is in \_\_\_\_\_\_\_\_\_\_\_of powering the stars.

b) The biggest difference between lepton and quarks is that leptons don’t have color \_\_\_\_\_\_\_\_\_\_\_.

c) The battery is on \_\_\_\_\_\_\_\_\_\_\_.

C.

a) The \_\_\_\_\_\_\_\_\_\_\_of the transmitter of the next generation may increase by 20 per cent.

b) The movement of this asteroid is still beyond the \_\_\_\_\_\_\_\_\_\_\_of vision.

c) Since W and Z bosons can’t move very far their \_\_\_\_\_\_\_\_\_\_\_of the weak force is very small.

**12. Use the words given in brackets to form a word that fits in the gaps.**

1. The neutron is one of the two kinds of elementary particles of which all \_\_\_\_\_ (nucleus) consist.
2. The other kind of particle and neutrons and protons are often called by the \_\_\_\_\_ (collect) name nucleons.
3. Neutrons and protons \_\_\_\_\_ (different), however, protons are\_\_\_\_\_ (charge) while neutrons have no charge at all.
4. Ordinary hydrogen gas is \_\_\_\_\_ (atom).
5. A plasma may be \_\_\_\_\_ (part) ionized, with only a fraction of the molecules ionized and the remainder \_\_\_\_\_ (electric) neutral.
6. Antimatter production is\_\_\_\_\_ (current) very limited, but has been growing at a nearly \_\_\_\_\_ (geometry) rate since the discoveries of the first\_\_\_\_\_ (proton) in 1955.
7. \_\_\_\_\_ (store) is another problem as antiprotons repel against each other.
8. Plasma \_\_\_\_\_ (oscillate) in the charged cloud of antiprotons can cause \_\_\_\_\_ (stable).
9. It is hoped that antimatter could be used as a fuel for \_\_\_\_\_ (planet) travel or \_\_\_\_\_ (star) travel.
10. The story of quantum physics has as many twists and turns as it has strange \_\_\_\_\_ (phenomenon).
11. At large distances there is an \_\_\_\_\_ (attract), but at closer distances there is a\_\_\_\_\_ (repel).
12. This interest is due in part to the wide \_\_\_\_\_ (occur) of the plasma state in astrophysical studies and in part to the various research programs in controlled thermonuclear reactions.

**13. Read the sentences and mark T (true) or F (false).**

1. The strong force causes nuclear reaction that has let the sun shine for billions of years.
2. Photons mediate the electromagnetic force between electrically charged particles.
3. Neutrinos are very light and hardly ever interact with ordinary matter.
4. Protons and neutrons are both made from quarks.
5. The weak force binds atomic nuclei together, making them stable.
6. The neutron consists of two up and one down quarks.

**14. Complete each sentence by matching it with the appropriate ending.**

|  |  |
| --- | --- |
| 1. The Standard model of particle physics is a theory which describes 2. Each quark carries 3. Leptons do not carry 4. The up-type leptons participate in 5. The down-type leptons carry 6. Particles of matter exchange 7. The weak and strong forces are effective only | 1. no electric charge; 2. at the level of subatomic particles; 3. any of the three color charges; 4. bosons with each other; 5. any color charge- they are color neutral; 6. electromagnetic interactions; 7. three of the four known fundamental interactions between elementary particles that make up all matter. |

**15. Choose the correct answer A, B, or C from the list below.**

In the early 20th century physicists knew that matter was 1)… of protons, neutrons and electrons. 2)… had described how, due to quantum theory, electrons arranged themselves in a series of 3)… around nucleus, like the orbits of planets around the Sun. The 4)… of the nucleus were even stranger. Despite their repelling positive charges, nuclei could host tens of protons alongside neutrons 5)… into a tiny hard kernel, bound by the precise strong nuclear force. But as more was learned from radioactivity about how nuclei broke apart or joined together, it became clear that more 6)… needed to be explained.

First, the burning of hydrogen into 7)… in the Sun, via fusion, implicates another particle, neutrino, which transforms 8)… into neutrons. In 1930, the neutrino’s existence was inferred to explain the decay of a neutron into a proton and electron-9)… radioactive decay. The neutrino itself was not discovered until 1956, having virtually no 10)… . So, even in the 1930s there were many loose ends. But in the 1940s and 50s other particles were sought and the collection grew.

1. A discovered B consisted C made up
2. A Newton B Niels Bohr C Dalton
3. A groups B shells C grid
4. A properties B composition C mass
5. A squeezed B pushed C compressed
6. A phenomena B events C facts
7. A oxygen B helium C deuterium
8. A protons B electrons C taus
9. A alpha B beta C gamma
10. A mass B electric charge C color charge

16. Read the text below and think of the word which best fits each space. Use only one word in each space. There is an example at the beginning (0)

Example: 0. **The**

The Standard Model was formulated in (0) **the** 1970s and established by experiments in the early 1980s. Nearly three decades (1) exacting experiments have tested and verified the theory (2) detail, confirming all of (3) predictions. In one respect, this success is rewarding (4) it confirms that we really understand, (5) a deeper level (6) ever before, (7) nature works. Paradoxically, the success has (8) been frustrating. (9) the advent of the Standard Model, physicists had become used (10) experiments producing unexpected new particles (11) other signposts to a new theory almost before the chalk dust had settled on the old one. They have (12) waiting 30 years for that (13) happen to the Standard Model

SPEAKING

**17. Answer the following questions.**

1. What is the Standard model?
2. What groups does it consist of? Can you describe them?
3. How do the fundamental forces differ from each other?
4. What ways did the scientists use to detect subatomic particles?
5. Why isn’t gravity included in Standard model?

**18. Complete these sentences with information that reflects your personal views.**

1. The Standard model is a successful theory of particle physics…

2. The biggest success of the Standard model is…

3. The biggest failure of the Standard model is…

**19. In pairs, role-play conversations in which a physicist explains the main ideas of the Standard model to a layperson.**

**20. In pairs or small groups, look for information on one of the topics from the list below and prepare an oral report.**

* How will the discovery of Higgs boson affect the Standard model?
* Do all the scientists support the Standard model?
* Is it possible to create a Unified theory?

**21. Test yourself.**

1. What are the states of matter? Describe five properties for each of them.
2. Draw out what the particles look like in a solid, a liquid and a gas.
3. Give the names of six changes of state, and say which state they go from and to.
4. Explain how gases exert a pressure on the insides of a container.
5. What happens to the pressure of a gas if the volume of the gas is decreased?
6. Explain what diffusion is. What’s it a bit like doing?
7. What is a compound? How is a compound different from a mixture?
8. Is it easy to split a compound back up into is original elements?
9. What is an alloy?
10. Why is diamond different from most non-metals? What is unusual about graphite?
11. What is atomic volume?
12. What are atomic radii?
13. What is an ion?
14. What is Octet rule?
15. What is Hund’s rule?

**22. Build an atom! If you want to play and take part in interactive simulations, go to**

phet.colorado.edu/en/simulation/build-an-atom

LISTENING

**23. Listen to ‘CERN the Standard Model of Particle Physics’ and choose the right answer.**

1. The objective of particle physicists is:
2. To understand the basic structure and laws of nature;
3. To create a unified theory of the structure of the universe;
4. To discover all elementary particles;
5. At first scientists supposed that an atom has:
6. a nucleus and electrons;
7. protons, neutrons and electrons;
8. leptons and quarks;
9. The scientists found many new elementary particles:
10. at the beginning of the 20th century;
11. at the end of the 19th century;
12. at the end of the 20th century;
13. all particles were organized according to their:
14. spin;
15. mass and an electrical charge;
16. properties;
17. the weak force explains:
18. the energy of the nucleus;
19. radioactive gamma decay;
20. the energy of the Sun and radioactive beta decay;
21. Quarks are glued together by gluons in:
22. Protons;
23. Neutrons;
24. Protons and neutrons;
25. Beyond the Standard Model there are many questions to be answered such as:
26. Superconductivity and wave-particle duality;
27. Supersymmetry and extra dimensions;
28. Black holes and antimatter;

**Funny Science Jokes**

1. What’s the difference between a quantum mechanic and an auto mechanic? The quantum mechanic can get inside without opening the door.

2. Who solves mysteries involving electricity? Sherlock Ohms.

DESCRIBING GRAPHS

**24. Look at the table, graph or figure and describe it.**

To understand and describe graphs and tables you should understand the following details:

*What is the information or data in the graph or table about?*

*What are the units of measurement used?*

*What are the area (place) involved?*

*What is the purpose of the graph or table?*

*What is the time-scale involved?*

This is the list of some introductory expressions which can be useful to begin the description of the graph or table with:

***The graph/ table shows / indicates/illustrates/ reveals/represents;***

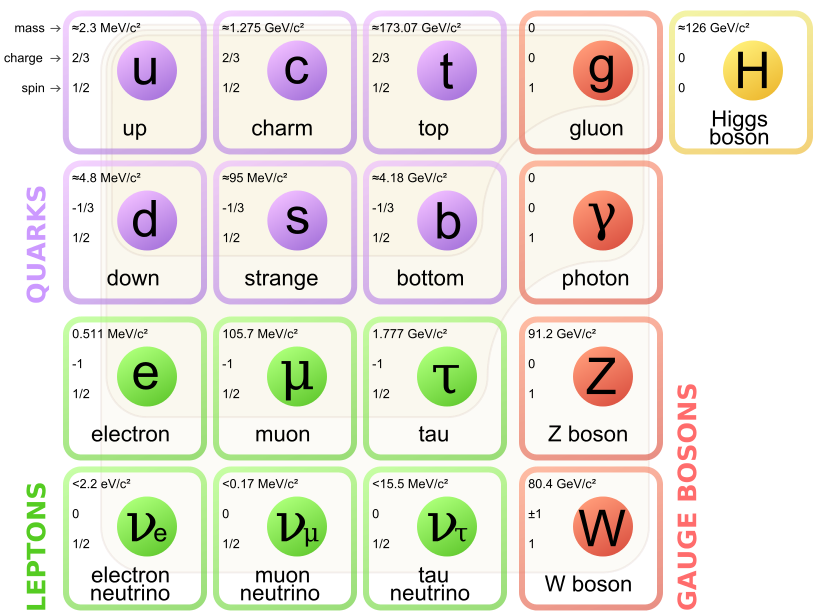
***It is clear from the graph/table;***

***It can be seen from the graph/table;***

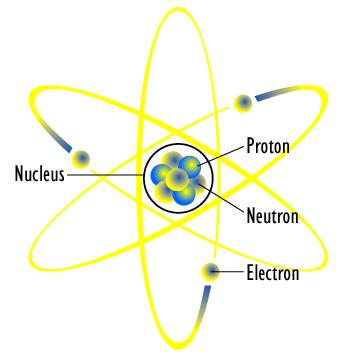
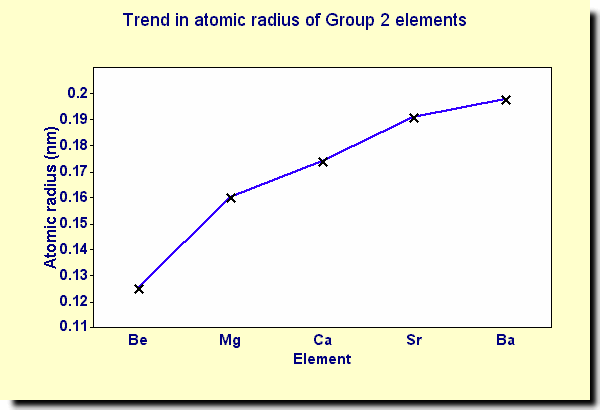
***As the graph/table shows;***

***From the graph/ table it is clear***

Notice that it is best to avoid using personal pronouns. Instead of saying *We can see from the graph* it is better to use the passive or impersonal constructions, as above.

**A.**

**B. C.**



WRITING

**23. Translate the paragraph into Russian.**

In 1934, Hideki Yukawa proposed that the nuclear force was carried by special particles (called mesons), that act in a similar way to photons. Protons and neutrons are glued together by exchanging mesons. Even now it is a mystery why the strong nuclear force acts on such a specific distance scale- why it is so weak outside the nucleus and so strong at close range. It is as if it locks the nucleons together at a precise distance. The strong nuclear force is one of the four fundamental forces, along with gravity, electromagnetism and another nuclear force called the weak force.

**24. Translate the paragraph into English.**

Слабое взаимодействие

Слабое взаимодействие введено в физику элементарных частиц для объяснения явления бета-распада ядра. Слабое взаимодействие проявляется на расстояниях значительно меньших радиуса ядра. В слабом взаимодействии участвуют лептоны, кварки и частицы нейтрино. Слабое взаимодействие слабее электромагнитного и сильнее гравитационного. Слабое взаимодействие позволяет лептонам и кваркам превращаться в античастицы, то есть обмениваться квантовыми числами, энергией, массой, электрическими зарядами. Переносчиками слабого взаимодействия являются виртуальные W- и Z - бозоны. Слабое взаимодействие нарушает все виды симметрии, позволяет кваркам одного аромата превращаться в кварки другого аромата, заряженным лептонам превращаться в нейтрино.

MINI GRAMMAR

ARTICLES

Articles can be difficult to use correctly: the rules are many and complex. Here are some of the most important rules.

ZERO ARTICLE

You don’t use articles with proper nouns such as places, people and companies.

*John Smith had a job with Microsoft but now he’s moved to IBM.*

Exceptions are when the article is part of a name (the BBC, the Beatles)

The indefinite article means ‘one’, so you don’t use it with plurals or uncountable nouns.

*There are plenty of ideas. The love of money is the root of all devil.*

In English, most abstract concepts are uncountable:

*After a few years of hard work…*

INDEFINITE ARTICLE: INTRODUCING/ CATEGORISING

When you first mention new people, places or objects etc., the most normal thing to do is to introduce them by saying what category they belong to. You use the indefinite article to show that this is what you are doing.

*There is a new report from IBM.*

DEFINITE ARTICLE: REFERRING/IDENTIFYING

When you identify something or refer to a specific thing, you use the definite article. This often happens for one of these two reasons.

Back reference:

*THERE was a young lady of Niger*

*Who smiled as she rode on a Tiger;*

*They came back from the ride*

*With the lady inside,*

*And the smile on the face of the Tiger.*

(The last three lines of the poem refer to things introduced in the first two)

Shared knowledge:

*You could use the devices and the results of the experiments in our lab.*

Back reference and shared knowledge can combine.

*He took a photograph. The click of the camera woke the man up.*

In general statements in English you don’t usually use the definite article with plural or uncountable nouns.

Here are some general rules for using articles:

* Don’t use articles (a/an, the) with most proper nouns.
* Don’t use the indefinite article (a/an) with plurals or uncountable nouns.
* Use the indefinite article (a/an) to introduce new information.
* Use the definite article (the) to refer to specific things which have already been mentioned.
* Use the definite article (the) to refer to things that you know the listener or hearer can identify.

**25. Read, translate the sentences, and explain the use of articles.**

1. The sun rotates on its axis just as the earth does, from west to east, but takes longer to complete a rotation.
2. Nature is a slave to periodicity. The seasons, the tides, darkness and light and of others are periodic or approximately so.
3. The close agreement of the six observations is unlikely to be a coincidence.
4. When an organization grows, both it and its procedures change.
5. A production system is composed of three elements: data, a set of rules, and an interpreter.
6. Assumptions have to be made.
7. An example is shown in Fig. 3
8. The difference between the two factors is due to different methods of estimating.
9. Several cases were studied and satisfactory results have been obtained.
10. In this case an analytical solution is unattainable.

APPENDIX

The names of the elements in English

1 - H - Hydrogen

2 - He - Helium

3 - Li - Lithium

4 - Be - Beryllium

5 - B - Boron

6 - C - Carbon

7 - N - Nitrogen

8 - O - Oxygen

9 - F - Fluorine

10 - Ne - Neon

11 - Na - Sodium

12 - Mg - Magnesium

13 - Al - Aluminum, Aluminium

14 - Si - Silicon

15 - P - Phosphorus

16 - S - Sulfur

17 - Cl - Chlorine

18 - Ar - Argon

19 - K - Potassium

20 - Ca - Calcium

21 - Sc - Scandium

22 - Ti - Titanium

23 - V - Vanadium

24 - Cr - Chromium

25 - Mn - Manganese

26 - Fe - Iron

27 - Co - Cobalt

28 - Ni - Nickel

29 - Cu - Copper

30 - Zn - Zinc

31 - Ga - Gallium

32 - Ge - Germanium

33 - As - Arsenic

34 - Se - Selenium

35 - Br - Bromine

36 - Kr - Krypton

37 - Rb - Rubidium

38 - Sr - Strontium

39 - Y - Yttrium

40 - Zr - Zirconium

41 - Nb - Niobium

42 - Mo - Molybdenum

43 - Tc - Technetium

44 - Ru - Ruthenium

45 - Rh - Rhodium

46 - Pd - Palladium

47 - Ag - Silver

48 - Cd - Cadmium

49 - In - Indium

50 - Sn - Tin

51 - Sb - Antimony

52 - Te - Tellurium

53 - I - Iodine

54 - Xe - Xenon

55 - Cs - Cesium

56 - Ba - Barium

57 - La - Lanthanum

58 - Ce - Cerium

59 - Pr - Praseodymium

60 - Nd - Neodymium

61 - Pm - Promethium

62 - Sm - Samarium

63 - Eu - Europium

64 - Gd - Gadolinium

65 - Tb - Terbium

66 - Dy - Dysprosium

67 - Ho - Holmium

68 - Er - Erbium

69 - Tm - Thulium

70 - Yb - Ytterbium

71 - Lu - Lutetium

72 - Hf - Hafnium

73 - Ta - Tantalum

74 - W - Tungsten

75 - Re - Rhenium

76 - Os - Osmium

77 - Ir - Iridium

78 - Pt - Platinum

79 - Au - Gold

80 - Hg - Mercury

81 - Tl - Thallium

82 - Pb - Lead

83 - Bi - Bismuth

84 - Po - Polonium

85 - At - Astatine

86 - Rn - Radon

87 - Fr - Francium

88 - Ra - Radium

89 - Ac - Actinium

90 - Th - Thorium

91 - Pa - Protactinium

92 - U - Uranium

93 - Np - Neptunium

94 - Pu - Plutonium

95 - Am - Americium

96 - Cm - Curium

97 - Bk - Berkelium

98 - Cf - Californium

99 - Es - Einsteinium

100 - Fm - Fermium

101 - Md - Mendelevium

102 - No - Nobelium

103 - Lr - Lawrencium

104 - Rf - Rutherfordium

105 - Db - Dubnium

106 - Sg - Seaborgium

107 - Bh - Bohrium

108 - Hs - Hassium

109 - Mt - Meitnerium

110 - Ds - Darmstadtium

111 - Rg - Roentgenium

112 - Cn - Copernicium

113 - Uut - Ununtrium

114 - Fl - Flerovium

115 - Uup - Ununpentium

116 - Lv - Livermorium

117 - Uus - Ununseptium

118 - Uuo - Ununoctium

**Part II “ANTIMATTER”**

*‘For every one billion particles of antimatter there were one billion and one particles of matter. And when the mutual annihilation was complete, one billionth remained - and that’s our present universe,’*

Albert Einstein, 1879-1955

LEAD-IN

**1. Discuss these questions with your partner.**

What is antimatter?

Where is all antimatter?

What can happen when matter and antimatter come into contact?

**2. Read the article and fill in the missing parts of sentences. One of them is extra.**

a) exist in only one form;

b) the photon and gluon look the same;

c) whether anti-hydrogen behaves;

d) a vast amount of matter and antimatter;

e) positive energy was expected;

f) to reveal the antiproton;

g) which are reversed;

h) the track of a positively charged particle.

THE MYSTERY OF ANTIMATTER

1. Fictional spaceships are often powered by ‘antimatter drives’, yet antimatter itself is real and has even been made artificially on Earth. The history of antimatter’s discovery began in 1928 when British physicist Paul Dirac saw that his equation for the electron offered the possibility that electrons could have negative as well as positive energy. Dirac had two ways of solving his problem: [1\_\_], associated with a normal electron, but negative energy made no sense. But rather than ignore this confusing term, Dirac suggested that such particles might actually exist. This complementary state of matter is antimatter.
2. The hunt for antimatter began quickly. In 1932 Carl Anderson confirmed the existence of positrons experimentally. He was following the tracks of showers of particles produced by cosmic rays. He saw [2\_\_] with the electron’s mass, positron. So antimatter was no longer just an abstract idea but real.
3. It took another two decades before the next antiparticle, the antiproton, was detected. Physicists built new particle-accelerating machines that used magnetic fields to increase the speeds of particles travelling through them. Such powerful beams of speeding protons produced enough energy [3\_\_] in 1955. Soon afterwards, the antineutron was found.
4. With the antimatter equivalent building blocks in place, was it possible to build an anti-atom, or at least an anti-nucleus? The answer was yes. A heavy hydrogen (deuterium) anti-nucleus (an anti-deuterium), containing an antiproton and antineutron, was created by scientists at CERN in Europe and Brookhaven Laboratory in America. Tagging on a positron to an antiproton to make a hydrogen anti-atom (anti-hydrogen) took a little longer, but it was achieved in 1995. Today experimenters are testing [4\_\_] in the same way as normal hydrogen.
5. On Earth, physicists can create antimatter in particle accelerators. When the beams of particles meet, they annihilate each other in a flash of pure energy. Mass is converted to energy according to Einstein’s E=mc2. So if you met your antimatter twin, it might not be such a good idea to throw arms around them.(A) If antimatter were spread across the universe, these annihilation episodes would be occurring all the time. (B) Matter and antimatter would gradually destroy each other in little explosions, mopping each other up.(C) In fact normal matter is the only widespread form of particle we see, by a very large margin.
6. Like all mirror images, particles and their antiparticles are related by different kinds of symmetry. One is time. Because of their negative energy, antiparticles are equivalent mathematically to normal particles moving backwards in time. So a positron can be thought of an electron travelling from future to past. The next symmetry involves charges and other quantum properties, [5\_\_], and is known as ‘charge conjugation’. A third symmetry regards motion through space. Returning to Mach’s principle, motions are generally unaffected if we change the direction of coordinates marking out the grid of space. A particle moving left to right looks the same as one moving right to left, or is unchanged whether spinning clockwise or anticlockwise. This ‘parity’ symmetry is true of most particles, but there are a few for which it does not always hold. Neutrinos [6\_\_], as a left-handed neutrino, spinning one direction; there is no such thing as a right-handed neutrino. The converse is true for antineutrinos which are all right-handed. So parity symmetry can sometimes be broken, although a combination of charge conjugation and parity is conserved, called charge-parity or CP symmetry for short.
7. Just as chemists find that some molecules prefer to exist in one version, as a left-handed or right-handed structure, it is a major puzzle why the universe contains mostly matter and not antimatter. A tiny fraction – less than 0.01% - of the stuff in the universe is made of antimatter. But the universe also contains forms of energy, including a lot of photons. So it is possible that [7\_\_] was created in the big bang, but then most of it annihilated shortly after. Only the tip of the iceberg now remains. A minuscule imbalance in favor of matter would be enough to explain its dominance now. To do this, only 1 in every 1010 matter particles needed to survive a split second after the big bang, the remainder being annihilated. The leftover matter was likely preserved via a slight asymmetry from CP symmetry violation.

**3. Look at three lettered spaces in the text (A),(B),(C) that indicate where the following sentence can be added to the passage.** **Where would the sentence best fit?**

*Because we don’t see this, there cannot be much antimatter around.*

**4. Read the text again and find the words that mean the same as the following definitions.**

1. Similarity under reflection or rotation or re-scaling;
2. A line of light, electric waves or particles;
3. Combination of some things;
4. Either of two numbers or letters used to fix the position of a point on a map or graph;
5. A statement showing that two amounts or values are equal;
6. The act or process of moving or the way something moves;
7. The state of being equal;
8. The rate at which sb/sth moves or travels;
9. The path or direction that sb/sth is moving in;
10. To destroy sb/sth completely.

**5. In pairs, discuss and write definitions for the following terms from the text. Use a dictionary to help you.**

|  |  |  |
| --- | --- | --- |
| antimatter  imbalance  minuscule  positron | fraction  particle  accelerator  to convert | pure  affect  to reverse  nucleus  equivalent |

**6. Read the sentences and mark T (true) or F (false).**

1. It is easy to produce antimatter in the form of anti-atoms.
2. Almost all matter observable from the Earth seems to be made of matter rather than antimatter.
3. Many different antiparticles are produced by cosmic rays.
4. An antiproton consists of one up anti-quark and two down anti-quarks.
5. Antiparticles are produced naturally in beta decay.
6. The neutron is made out of quarks, the antineutron from anti-quarks.
7. The parity symmetry is true to all particles.
8. An antiproton and a proton can form an anti-hydrogen atom .
9. Neutral particles can have antiparticles.

**7. Complete each sentence by matching it with the appropriate ending.**

|  |  |
| --- | --- |
| 1. Antiparticle bind with each other 2. Recent research by the American Astronomical Society has discovered antimatter 3. Antimatter in the form of charged particles can be contained 4. Since the antineutron is electrically neutral 5. The asymmetry of matter and antimatter in the visible universe is 6. Antiparticles are created naturally 7. Generating a single antiproton is | 1. Immensely difficult and required particles accelerators and vast amount of energy; 2. One of the greatest unsolved problems in physics; 3. To form antimatter just as ordinary particles bind to form normal matter; 4. By a combination of electric and magnetic fields; 5. When high-energy particle collisions take place; 6. It can’t be easily observed directly; 7. Originating above thunderstorm clouds. |

**8. Use the words given below to fill in the gaps.**

***annihilate, parity, equation, symmetry, coordinates, motion, conjugation, speed***

1. A particle has even \_\_\_\_\_\_\_\_\_\_\_if it doesn’t change when it is reflected from side to side or up and down.
2. Electrons and positrons may pop into existence in the vacuum of space, then \_\_\_\_\_\_\_\_\_\_\_
3. Antimatter is matter reflected in time, what is technically called a ’charge \_\_\_\_\_\_\_\_\_\_ transformation.
4. Velocity is \_\_\_\_\_\_\_\_\_\_\_in a particular direction.
5. The laws of planetary \_\_\_\_\_\_\_\_\_\_\_were developed by Kepler.
6. Physicists can use the \_\_\_\_\_\_\_\_\_\_\_of electromagnetism to explain the properties of the electron some distance away from the particle.
7. The Higgs boson was deduced for the purpose of breaking \_\_\_\_\_\_\_\_\_\_\_in electroweak interactions.
8. By solving Schrodinger’s equation, four quantum numbers are needed to describe any particle – three spatial\_\_\_\_\_\_\_\_\_\_\_ and the fourth one, spin.

**9. Choose the right option.**

1. According to the text Paul Dirac…
2. Ignored the presence of negative energy;
3. Found that his equation had negative-energy solution;
4. Suggested that anti-electrons exist.
5. The first evidence of positrons existence…
6. was obtained with the help of particle accelerators;
7. was discovered in space;
8. was experimentally produced by Carl Anderson in his lab.
9. The first antiproton was discovered in…
10. 1932;
11. 1955;
12. 1952
13. To make an anti-hydrogen the physicists…
14. Join antiproton and antineutron;
15. Join a positron and an anti-proton;
16. Split tritium into anti-deuterium and deuterium;
17. When the beams of particles and antiparticles meet, they annihilate each other and…
18. Their mass is converted into energy;
19. New virtual particles appear instead;
20. They combine into photon which has zero movement in time.

**10. Choose the phrase which could replace parts of these phrases.**

1. was no longer
2. Was shorter;
3. Was not possible then;
4. Didn’t exist
5. tagging on a positron to an antiproton
6. Converting a positron into an antiproton;
7. Connecting a positron and an antiproton;
8. Replacing a positron by an antiproton
9. to throw arms around them
10. To embrace;
11. To hit them;
12. To throw something to them
13. minuscule imbalance
14. Negative disproportion;
15. Great violation of balance;
16. Infinitesimal difference in the amount
17. dominance
18. prevalence;
19. suppression;
20. superiority
21. the leftover matter
22. antimatter;
23. the rest of matter;
24. the lack of matter

**11. For each set find one word mentioned in the text that will fit all sentences.**

(1)

a) Think of a\_\_\_\_\_\_\_\_\_\_\_ and multiply it by three.

b) Elements are listed in order of atomic\_\_\_\_\_\_\_\_\_\_\_.

c) The\_\_\_\_\_\_\_\_\_\_\_ of protons in the nuclei of different elements is different.

(2)

a) Students have a \_\_\_\_\_\_\_\_\_\_\_choice of courses in their final year.

b) For their studies students get a \_\_\_\_\_\_\_\_\_\_\_ access to the internet.

c) \_\_\_\_\_\_\_\_\_\_\_radicals in the body are thought to be one of the causes of diseases.

(3)

a) \_\_\_\_\_\_\_\_\_\_\_ travels more slowly than the light.

b) We arrived home safe and \_\_\_\_\_\_\_\_\_\_\_.

c) The researchers use a novel device to \_\_\_\_\_\_\_\_\_\_\_the depth of the sea.

**12. Use the words given in brackets to form a word that fits in the gaps.**

1) A \_\_\_\_\_\_\_\_\_\_\_ (replicate) of this barometer may be constructed in the laboratory.

2) Superconductors have unlimited \_\_\_\_\_\_\_\_\_\_\_ (conduct).

3) Heat reflects\_\_\_\_\_\_\_\_\_\_\_ (molecule) vibrations.

4) The \_\_\_\_\_\_\_\_\_\_\_ (solve) came from the German physicist Max Planck, who was trying to unify the physics of heat and light at the time.

5) Using Huygens’ approach, the wave energy sources at the edge of the gap radiate circular ripples, making the wave look almost \_\_\_\_\_\_\_\_\_\_\_ (circle) after it has gone through.

6) To avoid\_\_\_\_\_\_\_\_\_\_\_ (confuse) with hydrogen gas itself, in 1920 Rutherford named the bare hydrogen nucleus the ‘proton’, after the Greek for the ‘first’.

7) Each element produces a characteristic set of \_\_\_\_\_\_\_\_\_\_\_ (spectrum) lines, like a sort of musical scale in light.

8) Scientists performed some tests, showing that the\_\_\_\_\_\_\_\_\_\_\_ (nucleus) of some atoms have quantized angular momentum.

9) For something less than half a per cent of the mass of the target atom, the neutron’s impact on the uranium seemed \_\_\_\_\_\_\_\_\_\_\_ (excess).

10) Niels Bohr believed that the nucleus was like a liquid drop and forces of surface tension should resist the droplet’s \_\_\_\_\_\_\_\_\_\_\_ (divide), and even if it did split then the two positively charged drops of substance would repel and fly apart.

**13. For each set find one word mentioned in the text that will fit all sentences.**

(A)

1) Can you give me some\_\_\_\_\_\_\_\_\_\_\_ how to use these equations?

2) The \_\_\_\_\_\_\_\_\_\_\_ of the rods inside the tubes were covered with ice.

3) A waiter usually expects to get some\_\_\_\_\_\_\_\_\_\_\_ .

(B)

1) All results of the experiments differ in \_\_\_\_\_\_\_\_\_\_\_ .

2) What \_\_\_\_\_\_\_\_\_\_\_ of research are you going to do?

3) He was too\_\_\_\_\_\_\_\_\_\_\_ to tell you ‘no’.

(C)

1) This statement doesn’t make\_\_\_\_\_\_\_\_\_\_\_ .

2) A\_\_\_\_\_\_\_\_\_\_\_ of duty made outstanding scientists join against the beginning of robot soldiers production;

3) He had the \_\_\_\_\_\_\_\_\_\_\_ to turn off the device when he felt smoke in the lab.

SPEAKING

**14. Answer the following questions.**

1. How did Paul Dirac come to the idea of the existence of antimatter?
2. Where did the researchers get the first results in this field?
3. How did it become possible to build an anti-atom and anti-nucleus?
4. How can antimatter be built on Earth?
5. What are the consequences of meeting particles and antiparticles?
6. What kinds of symmetry are particles and antiparticles related by?
7. What does parity symmetry mean?
8. How does the author explain the dominance of matter in the universe?

**15. In pairs, role-play conversations in which a physicist explains to a layperson:**

*why the formation of matter after the Big Bang resulted in a universe consisting almost entirely of matter, rather than being a half-and half mixture of matter and antimatter.*

**16. Look at the diagram and describe it.**

The purpose of a diagram is normally to show a process, how a piece of equipment works, or an operational structure of a system. The vocabulary will mostly be closely related to the special subject being shown. There are two aspects of the language that you will require for describing most diagrams and you should make sure that you know how to use them well:

The verbs will normally be in the present tense and the passive voice.

Where a process or structure is being presented, you will need a variety of connectors showing stages or time.

Do not attempt to describe the diagram in colorful or interesting language. There is no need for adjectives or adverbs.

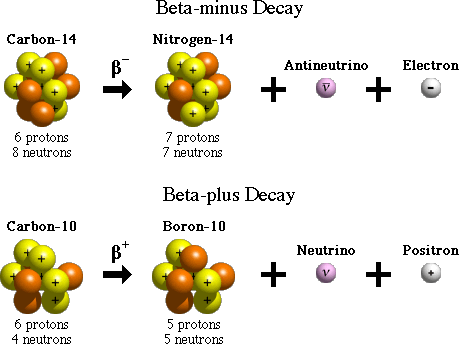
Avoid repetition and try to vary your language.

Do not simply use ***firstly, secondly***, etc. or ***then*** to link different stages.

Here are some other possibilities:

***In the first/second/etc. stage…***

***Next…***

***The process continues with…***

***After this****…*

You can also use ***then*** after the subject of your sentence, instead of the beginning:

*The water is then transported*.

**17. In pairs or small groups, choose any topic from the list below and prepare an oral report.**

1. Gravity works the same way on all matter – but what about antimatter?
2. Could we make an anti-world?
3. Could antimatter be used to make the ultimate bomb?

**18. Test yourself.**

1. Can neutrons be transmuted into anti-neutrons?
2. Where is all antimatter?
3. Does antigravity exist? Why do you think so?
4. Do antiparticles attract other antiparticles?
5. Why didn’t matter and antimatter annihilate just after the Big Bang?
6. How do scientists make antimatter?
7. Is it possible to keep obtained antiparticles?
8. What is formed after annihilation of matter and antimatter?
9. Can antimatter be used as fuel?
10. Can it have practical medical applications?

LISTENING

**19. Listen to ‘What Happened to Antimatter?’ and complete the notes. Check and compare your answers.**

1. Can energy be made into matter? How?
2. What does 50/50 mean here?
3. What happens at CERN’s Large Hadron Collider every second?
4. What do an electron and a positron have in common?
5. How do they differ from protons and anti-protons?
6. How would an anti-world look like?
7. Why didn’t matter annihilate after the colliding with anti-matter after the Big Bang?

WRITING

**20. Translate the paragraph into Russian.**

Universal Asymmetries

If antimatter were spread across the universe, the annihilation episodes would be occurring all the time. Matter and antimatter would gradually destroy each other in little explosions, mopping each other up. Because we don’t see this, there cannot be much antimatter around. In fact normal matter is the only widespread form of particle we see, by a very large margin. So at the outset of the creation of the universe there must have been an imbalance such that more normal matter was created than its antimatter opposite.

**21. Translate the paragraph into English.**

Ёще в 2002 году в Европейском центре ядерных исследований физики впервые получили ощутимое количество антивещества- примерно 50 тысяч атомов антиводорода. Но всё полученное антивещество мгновенно самоуничтожилось, взаимодействуя с нормальным веществом. Ныне физикам удалось собрать полученные атомы в хитрую ловушку- так называемою «магнитную бутылку». Им удалось воспроизвести 38 атомов антиводорода, некоторые из них просуществовали одну десятую долю секунды, что дало ученым достаточную почву для их изучений.

**Part III “NUCLEAR FISSION”**

*‘…gradually we came to the idea that perhaps one should not think of the nucleus being cleaved in half as with a chisel but rather that perhaps there was something Bohr’s idea that the nucleus was like a liquid drop.’*

Otto Frisch, 1967

LEAD-IN

**1. In pairs or small groups, discuss the questions.**

What is nuclear fission?

Why is nuclear power used to produce electricity?

Why is nuclear power very dangerous?

**2. Arrange the sentences of the last paragraph in the right order.**

**3. Read and complete the text using the words below.**

NUCLEAR FISSION

1. The demonstration of nuclear fission is one of the great highs and lows of science. Its discovery marked a huge 1) \_\_\_\_\_\_\_\_\_in our understanding of nuclear physics, and broke the dawn of atomic energy. But the umbrella of war meant this new 2) \_\_\_\_\_\_\_\_\_was implemented almost immediately in nuclear weapons, devastating the Japanese cities of Hiroshima and Nagasaki and unleashing a proliferation problem that remains difficult to resolve.
2. At the start of the 20th century, the atom’s 3) \_\_\_\_\_\_\_\_\_world began to be revealed. Like a Russian doll, it contains many 4) \_\_\_\_\_\_\_\_\_shells of electrons enveloping a hard kernel or nucleus. By the early 1930th, the nucleus itself was 5) \_\_\_\_\_\_\_\_\_, showing it to be a mix of positively charged protons and uncharged neutrons, both much heavier than the ephemeral electron, and bonded together by the strong nuclear force. Unlocking the energy glue of the nucleus became a holy grail of scientists.
3. In nuclear physics and nuclear chemistry, nuclear fission is a nuclear reaction in which the nucleus of an atom 6) \_\_\_\_\_\_\_\_\_into smaller parts, often producing free electrons and lighter nuclei, which may eventually produce photons (in the form of gamma rays). Fission of heavy elements is an exothermic reaction which can release large amounts of energy both as electromagnetic radiation and as kinetic energy of the fragments (heating the bulk material where fission takes place). For fission to produce energy, the 7) \_\_\_\_\_\_\_\_\_binding energy of the resulting elements has to be higher than that of the starting element. Fission is a form of nuclear transmutation because the resulting fragments are not the same element as the original one.
4. Nuclear fission produces energy for nuclear power and to drive the explosions of nuclear weapons. Both uses are made possible because certain substances called nuclear fuels undergo fission when struck by 8) \_\_\_\_\_\_\_\_\_neutrons and in turn generate neutrons when they break apart. This makes possible a self- sustaining chain reaction that releases energy at a controlled rate in a nuclear reactor or at a very rapid uncontrolled rate in a nuclear weapon.
5. The amount of free energy contained in nuclear fuel is millions of times the amount of free energy 9) \_\_\_\_\_\_\_\_\_in a small mass of chemical fuel such as gasoline, making nuclear fission a very tempting source of energy; however, the products of nuclear fission are radioactive and 10) \_\_\_\_\_\_\_\_\_so for significant amounts of time, giving rise to a nuclear waste problem.
6. 1. \_\_ Plutonium-239 is unstable and its breakdown produces even more neutrons per gram, so mixing in plutonium can trigger the chain reaction readily. 2. \_\_ It is uranium-235 that is the most effective for a fission bomb, so raw uranium is enriched in uranium-235. 3. \_\_ Uranium comes in two types, or isotopes, hosting different numbers of neutrons in their nuclei. 4. \_\_ In nature, very few materials exist that undergo nuclear reaction. 5. \_\_ The most common isotope, uranium-238 is ten times more common than the other, uranium-235. 6. \_\_ When uranium-238 receives a neutron it becomes plutonium-239.

|  |  |  |
| --- | --- | --- |
| splits  outer  cracked  free | remain  leap  total | contained  technology  inner |

**4. Read the text again and find the words that mean the same as the following phrases.**

1. producing heat;
2. completely destroying something;
3. was officially decided to be used;
4. a place, person or thing that you get something from;
5. experience sth, a change or sth unpleasant;
6. the increase in the number or amount of something;
7. changing something into something different;
8. an object that is used for fighting or attacking;
9. covering something completely;
10. maintaining or able to maintain oneself or itself by independent effort.

**5. In pairs, discuss and write definitions for the following terms from the text.**

|  |  |  |
| --- | --- | --- |
| fission  isotope  radioactive | raw  trigger  substance | explosion  fuel  kinetic  split |

**6. Choose the phrase which could replace these phrases.**

1. the great highs and lows of science
2. achievements in scientific development;
3. successes and failures in scientific development;
4. different directions in science;
5. broke the dawn of atomic energy
6. gave the start of it;
7. prevented its development;
8. encouraged production of nuclear weapon;
9. unleashing a proliferation problem
10. succeeding in its solution;
11. attempting to solve it;
12. promoting its spread;
13. unlocking the energy glue of the nucleus
14. discovering nucleus as a source of energy;
15. discovering the structure of nucleus;
16. discovering the nucleus as a source of electricity;
17. a tempting source of energy
18. a profitable way of getting electricity;
19. an attractive way of getting energy;
20. a reliable way of getting energy.

**7. Fill the gaps with the new words:**

***devastate, transmutation, self-sustain, trigger, kinetic, raw, proliferation, envelope(v), split, exothermic***

1) Purifying uranium was hard, and neutrons in the experiments were quickly mopped up before they could\_\_\_\_\_\_\_\_\_\_ the fission cascade.

2) Fermi obtained the first\_\_\_\_\_\_\_\_\_\_ chain reaction in 1942 at the University of Chicago.

3) The work of the research team of the Manhattan Project was\_\_\_\_\_\_\_\_\_\_ in mystery.

4) Speed or velocity can be used to calculate the\_\_\_\_\_\_\_\_\_\_ energy.

5) In1917 Ernest Rutherford got \_\_\_\_\_\_\_\_\_\_ of nitrogen into oxygen by firing alpha particles at the gas.

6) Fermi was\_\_\_\_\_\_\_\_\_\_ when his theory of full beta decay was rejected by scientific journal Nature on the basis that it was too speculative.

7) We say the gas is ionized, which means that some of gas molecules have been\_\_\_\_\_\_\_\_\_\_ into positive ions and negative electrons.

8) A \_\_\_\_\_\_\_\_\_\_ of personal computers has greatly influenced the development of technologies.

9) \_\_\_\_\_\_\_\_\_\_ uranium is enriched to be used in the production a sustainable fission.

10) During \_\_\_\_\_\_\_\_\_\_ reaction some heat is released.

**8. Use the words given in brackets to form a word that fits in the gaps.**

1. Dirac thought of the quanta as tiny\_\_\_\_\_\_\_\_\_\_ (oscillate) .
2. Beta radiation involved the\_\_\_\_\_\_\_\_\_\_ (convert) of a down quark in a neutron into an up quark in a proton, while emitting a W-particle.
3. Interference effects are easily\_\_\_\_\_\_\_\_\_\_ (understand) if one thinks of a wave as some sort of displacement in a medium.
4. A sphere has the smallest possible surface area for a given mass, and therefore minimizes neutron\_\_\_\_\_\_\_\_\_\_ (leak) .
5. The amount of critical mass of fissile material is \_\_\_\_\_\_\_\_\_\_ (depend) on several factors: physical properties and nuclear properties, their geometry and purity.
6. In fact, the energy in a few grams of antimatter is enough to transport an\_\_\_\_\_\_\_\_\_\_ (man) spacecraft to Mars in about a month.
7. Fission chain reactions occur because of interactions between neutrons and \_\_\_\_\_\_\_\_\_\_ (fission) isotopes.
8. Questions remained about what the numbers in the \_\_\_\_\_\_\_\_\_\_ (matrix) were and what they meant in real life.
9. The universe is a sea of information; the form we assign to it is\_\_\_\_\_\_\_\_\_\_ (second) .
10. The \_\_\_\_\_\_\_\_\_\_ (come) electron, or other particle, absorbs a photon to produce a second more energetic electron.

SPEAKING

**9. Answer the following questions.**

1. What kind of energy is released during a nuclear reaction?
2. Why is it possible to use nuclear fission to produce electricity?
3. Why is the use of nuclear fuel more advantageous than chemical fuel?
4. How does uranium-238 become plutonium-239?

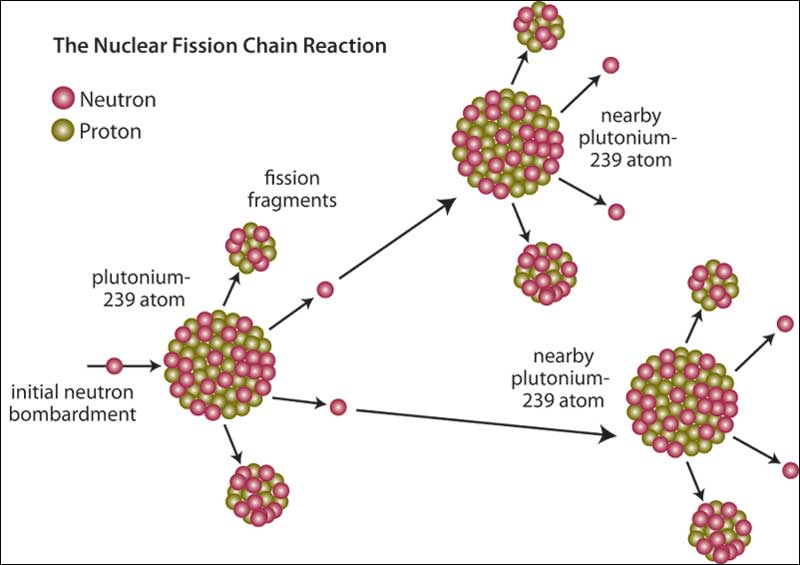
**10. Complete these sentences with information that reflects your personal views.**

1. To obtain energy by manipulating one or several nuclei of atoms we can do it using two ways…
2. Not all neutrons are able to continue the fission reaction…
3. The amount of critical mass of fissile material is dependent on several factors…
4. In order to enrich uranium…

**11. Read the statements and mark T (true) or F (false).**

1. In spontaneous nuclear fission the outer absorption is necessary.
2. Plutonium-239 has a low spontaneous fission rate compared with the rate of spontaneous fission of uranium-235.
3. Nuclear fission cannot occur without neutron bombardment.
4. During nuclear fission the sum of the masses of the fragments is smaller than the original mass.
5. The critical mass is the biggest amount of fissile material for a nuclear chain reaction is maintained.
6. The amount of critical mass of fissile material doesn’t depend on its purity.
7. The most common use of controlled nuclear fission is in nuclear reactors.
8. The self- sustaining release of neutrons is known as a chain reaction.

**12. Look at the diagram and describe it.**



**13. Complete each sentence by matching it with the appropriate ending.**

|  |  |
| --- | --- |
| 1. In nuclear energy we call nuclear fission the action 2. During a nuclear reaction the core becomes different fragments 3. Nuclear fission occur when a nucleus of o heavy atom 4. A nuclear chain reaction is a process by which neutrons are released in a first nuclear fission 5. Controlled reactions would be produced in nuclear reactions in nuclear plants that 6. If two neutrons are released in each fission caused by a neutron 7. If neutrons released by each nuclear reaction are lost faster than they are formed by the fission rate 8. Light water is the term used | 1. the chain reaction will not be self-sustaining and will stop. 2. produce additional fission in at least one more core. 3. having a mass almost equal to half of the original mass and two or three neutrons. 4. to describe water made using the common isotope protium, which has a single proton in its nucleus. 5. then the number of fissions doubles on each generation. 6. to split the nucleus of an atom. 7. captures a neutron, or can occur spontaneously due to the instability of the isotope. 8. generate electricity where their objective is steadily |

**14. In pairs, role-play a conversation in which a scientist explains a layperson what nuclear fission is.**

**15. Test yourself.**

1. Write down the nuclear equation for the alpha decay of:

a) 23892 U b)  23090Th с) 24195 Am

1. Write down the nuclear equation for the beta decay of:

a) 23490Th, b) 9038 Sr, c) 13153 I.

1. Give a proper definition of half-life.
2. Briefly describe what nuclear radiation does to living cells.
3. Why are alpha particles so good at ionizing atoms?
4. What is the main difference between X-rays and gamma rays?
5. Describe in detail how radioactive sources are used in each of the following:

a) treating cancer, b) tracers in medicine

1. Describe in detail how radioactive sources are used in each of the following:

a) tracers in industry, b) smoke alarms.

1. What type of particle is uranium-235 bombarded in a nuclear reactor to make it split?
2. An old bit of cloth was found to contain 1 part in 80 000 000 carbon-14. If carbon-14 decays with a half-life of 5730 years, find the age of the cloth.
3. Explain how a chain reaction is created in a nuclear reactor.

**16. In pairs or small groups look for information on one of the topics from the list below and prepare an oral report.**

1. Tell how a nuclear reactor works.
2. Tell about the latest achievements in nuclear research.
3. Tell about applications of nuclear power.

LISTENING

**17. Listen and watch ‘What is nuclear fission’ and do the task.**

**Answer the questions:**

1. What scientist first observed emitted radiation?
2. What scientist discovered a neutron?
3. Who first researched the phenomenon of radioactitvity?
4. When was the first reaction of nuclear fission obtained?
5. Where and when did scientists obtain the first self-sustained nuclear reaction?
6. How many protons and neutrons does uranium-235 consist of?
7. How much energy does this isotope release emitting 3 electrons and 1 neutron?
8. Where is nuclear power used nowadays?

WRITING

**18. Translate the paragraph into Russian.**

The Controlled Nuclear Reaction

To maintain a sustained nuclear reaction control for every two or three neutrons released, only one should be allowed to give another uranium nucleus. If this ratio is less than the one then the reaction will die, and if it is larger will grow uncontrollably. To control the amount of free neutrons in the reaction space an absorber of neutrons must be present. Most reactors are controlled by control rods made of neutron absorbing material in a strong, like boron or cadmium. In addition to the need to capture neutrons, the neutrons often have high kinetic energy. These fast neutrons are reduced through the use of a moderator, such as heavy water and tap water. Some reactors use graphite as a moderator, but this design has some problems. Once the fast neutrons are slowed they are more likely to produce more nuclear fissions or be absorbed by the control bar.

**19. Translate the paragraph into English.**

ПОЧЕМУ ИЗОТОПЫ РАСПАДАЮТСЯ?

В ядре атома находятся протоны, которые сконцентрированы в очень малом пространстве. В ядре атома действуют некие удерживающие силы, которые не дают одноименно заряженным нейтронам разорвать ядро атома. Но иногда энергия отталкивания частиц превосходит энергию склеивания, и ядро раскалывается на части - происходит радиоактивный распад.

Ученые установили, что все химические элементы, в ядре которых более 84 протонов, являются нестабильными и время от времени подвергаются радиоактивному распаду. Однако, существуют изотопы, в ядре которых меньше 84 протонов, но они тоже являются радиоактивными. Дело в том, что о стабильности изотопа можно судить по соотношению количества протонов и нейтронов атома. Изотоп будет нестабилен, если разность между количеством протонов и нейтронов велика. Изотоп элемента будет устойчивым, если количество нейтронов и протонов в его атоме примерно равно. Поэтому, неустойчивые изотопы, подвергаясь радиоактивному распаду, превращаются в другие элементы. Процесс превращения будет идти до тех пор, пока не образуется устойчивый изотоп.

**Part IV “NUCLEAR FUSION”**

*‘I ask you to look both ways. For the road to a knowledge of the stars leads through the atom; and important knowledge of the atom has been reached through the stars’*

Sir Arthur Eddington, 1928

LEAD-IN

**1. In pairs or small groups, discuss the questions.**

What is nuclear fission?

Why are researchers trying to get fusion power on Earth?

Do you believe that they will succeed in this field? Why?

**2. Read and complete the text using the phrases below.**

NUCLEAR FUSION

1. All elements around us, including those in our bodies, are the product of nuclear fusion. Fusion powers stars like the Sun, within which all the elements heavier than hydrogen are cooked up. We really are made of stardust. If we can harness the stars’ power on Earth, fusion [1 \_\_] .
2. Nuclear fusion is the merging together of light atomic nuclei to form heavier ones. When pressed together hard enough, hydrogen nuclei can merge to produce helium, giving off energy – a great deal of energy – in the process. Gradually, by building up heavier and heavier nuclei through a series of fusion reactions, all the elements that we see around us can be created from scratch.
3. Fusing together even the lightest nuclei, such as hydrogen, is tremendously difficult. Enormous temperatures and pressures are needed, so [2 \_\_], like the Sun and other stars. For two nuclei to merge, the forces that hold each one together must be overcome. Nuclei are made up of protons and neutrons locked together by the strong nuclear force. The strong force is dominant at the tiny scale of the nucleus, and is much weaker outside the nucleus. Because protons are positively charged, their electrical charges repel one another, so pushing each other apart slightly as well. But the strong force glue is more powerful so the nucleus holds together.
4. Because the strong nuclear force acts over such a short precise range, its combined strength is greater for small nuclei than for large ones. For a weighty nucleus, such as uranium, with 238 nucleons, the mutual attraction will not be as strong between nucleons on opposite sides of the nucleus. The electric repulsive force, on the other hand, [3 \_\_] and so becomes stronger for large nuclei because it can span the whole nucleus. It is also boosted by the greater numbers of positive charges they contain. The net effect of this balance is that the energy needed to bind the nucleus together, averaged per nucleon, increases with atomic weight up to the elements nickel and iron, which are very stable, then drops off again for larger nuclei. So fission of large nuclei happens relatively easily as they can be disrupted by a minor knock.
5. For fusion, the energy barrier to overcome is least for hydrogen isotopes that contain just a single proton. Hydrogen comes in three types: ‘normal’ hydrogen atoms contain one proton surrounded by a single electron; deuterium, or heavy hydrogen, has one proton, one electron and also one neutron; tritium has two neutrons added, so it is even heavier. The simplest fusion reaction therefore is [4 \_\_] a lone neutron. Although it is the simplest, scorching temperatures of 800 million kelvins are needed to ignite even this reaction.
6. On Earth, physicists are trying to replicate these extreme conditions in fusion reactors to generate power. However, they are decades [5 \_\_]. Even advanced fusion machines take in more energy than they give out, by orders of magnitude. Fusion power is the holy grail of energy production. (A) Very few atoms are needed to produce huge amounts of energy, there is little waste and certainly nothing as nasty as ultraheavy elements that come out of fission reactors. (B) Fusion power doesn’t produce greenhouse gases either, promising a self-contained, reliable source of energy assuming its fuel, hydrogen and deuterium, can be manufactured. (C)
7. Off from achieving this in practice;
8. Is still felt at larger separations;
9. Could even be the key to unlimited clean energy;
10. The combination of hydrogen and deuterium to form tritium plus;
11. Fusion only happens naturally in extreme places.

**3. Look at the three lettered spaces in the text (A), (B), (C) that indicate where the following sentence can be added to the passage. Where would the sentence best fit?**

*Compared with fission technology, fusion reactions are relatively clean and, should they work, efficient.*

**4. Read the text again and find the words that mean the same as the following phrases.**

1. used to describe actions that affect two or more things equally;
2. to succeed in dealing with or controlling something;
3. a range of levels or numbers used for measuring something;
4. closely connected with something;
5. made something increase, or become better;
6. made it difficult for something to continue in the normal way;
7. to become fewer or less;
8. to control and use the force or strength of something to produce power or achieve something;
9. to start or make something to burn;
10. to combine or make two or more things to form a single thing.

**5. In pairs or small groups discuss the definitions for the following terms from the text.**

|  |  |  |
| --- | --- | --- |
| nucleons  span  atomic  weight | a Kelvin  replicate  give off  reactor | to press  generate  power |

**6. Fill the gaps with the new words:**

***ignite, surround, disrupt, mutual, scale, merge, harness***

1. The material traversed by the charged particle is in a state of chemical combination, and then the moving field of electrical force may \_\_\_\_\_\_\_\_\_\_ the molecules.
2. Fractals are patterns that look essentially the same at any \_\_\_\_\_\_\_\_\_\_
3. Scientists all over the world have been trying to \_\_\_\_\_\_\_\_\_\_ the sun’s rays as a source of energy.
4. Ideas were again shared the Atlantic, but it still proved difficult to\_\_\_\_\_\_\_\_\_\_ a chain reaction in the laboratory.
5. In physics and nuclear chemistry, nuclear fusion is the process by which multiple atomic particles\_\_\_\_\_\_\_\_\_\_ to form a heavier nucleus.
6. They soon discovered a \_\_\_\_\_\_\_\_\_\_ interest in superconductivity.
7. Fermi found that, if the neutron source were \_\_\_\_\_\_\_\_\_\_ by water, or any substance containing a large proportion of hydrogen, it frequently was more efficient in producing radioactivity.

**7. What does the author mean by saying the following? Choose the best explanation.**

1. all elements heavier than hydrogen are cooked up
2. All the elements except hydrogen burn up at extreme temperatures;
3. All the elements whose atomic weight is bigger than hydrogen’s merge and release a lot of energy at extreme temperatures;
4. All heavy elements turn into light hydrogen at extreme temperatures;
5. We really are made of stardust
6. Our Earth is polluted by stardust;
7. Human bodies absorb a lot of star dust;
8. Everything on our planet is made of elements having been produced during fusion reactions on the Sun;
9. For two nuclei to merge, the forces that hold each one together must be overcome.
10. To make two nuclei join is very difficult because all nuclei have a positive charge, and they strongly resist being put too close together;
11. To make two nuclei join is difficult because gravitational force prevents it;
12. To make two nuclei join together is difficult because the strong force is more powerful than other forces;
13. They are decades off from achieving this in practice
14. In twenty years it will be possible to get energy from the first fusion reactors;
15. Nowadays scientists can’t predict when they will be able to get energy from the fusion reactors;
16. No scientists in the world are seriously working on getting artificial thermonuclear energy on our planet;
17. Fusion power is the holy grail of energy production
18. It will become the source of the unlimited clean energy;
19. It will be very profitable for energy industry;
20. It will completely change some laws in physics.

**8. For each set find one word mentioned in the text that will fit all sentences.**

(A)

1) They obtained the results like \_\_\_\_\_\_\_\_\_\_\_

2) Men work in a \_\_\_\_\_\_\_\_\_\_\_ to extract coal, gold and other minerals.

3) During a war soldiers use\_\_\_\_\_\_\_\_\_\_\_ to explode tanks.

(B)

1) A \_\_\_\_\_\_\_\_\_\_\_ provides various financial services, for example keeping or lending money.

2) It’s located on the left \_\_\_\_\_\_\_\_\_\_\_ of the Thames.

3) The sun disappeared behind a \_\_\_\_\_\_\_\_\_\_\_ of clouds.

(C)

1) Only \_\_\_\_\_\_\_\_\_\_\_ vehicles are allowed over the old bridge.

2) A \_\_\_\_\_\_\_\_\_\_\_ was still burning in the room.

3) Don’t turn on the \_\_\_\_\_\_\_\_\_\_\_. It’s not dark yet.

**9. Fill in the gaps with words derived from the words in brackets.**

1. \_\_\_\_\_\_\_\_\_\_\_ (gas) condition is important, even at low pressures.
2. If we consider a distribution of hydrogen in equilibrium at zero temperature, the presence of the matter produces a\_\_\_\_\_\_\_\_\_\_\_ (curve) of space.
3. Brief descriptions of the most important instruments, and of the methods of observing the phenomenon along with the \_\_\_\_\_\_\_\_\_\_\_ (criterion) used, are given in this chapter.
4. A high degree of accuracy is sometimes sacrificed for \_\_\_\_\_\_\_\_\_\_\_ (simple) in order to meet these demands.
5. This fact is not representative of the connection between the movement of the plasma \_\_\_\_\_\_\_\_\_\_\_ (regular) in the ionosphere and the state of the geomagnetic field.
6. During the experiment electric and magnetic fields cause \_\_\_\_\_\_\_\_\_\_\_ (deflect) of moving charged nuclei which depend on the mass of the nuclei.
7. In atomic reactions electrons are conserved and act as \_\_\_\_\_\_\_\_\_\_\_ (destruct) particles.
8. It can support entirely new kind of \_\_\_\_\_\_\_\_\_\_\_ (compute) with\_\_\_\_\_\_\_\_\_\_\_ (quality) new algorithms based on quantum principles.
9. Both \_\_\_\_\_\_\_\_\_\_\_ (radius) of curvature may be changed, but the difference in curvature is kept constant by bending the lens.
10. These systems produce a \_\_\_\_\_\_\_\_\_\_\_ (sphere) focal surface, and when they are used for cameras the film must be curved to fit this focal surface.

**10. Choose the correct answer A, B, or C from the list below.**

Natural Occurrence

In nature, fusion occurs in stars. On Earth, nuclear fusion was first achieved in the explosion of the 1) \_\_\_\_\_\_\_\_\_bomb. In a non-destructive manner, fusion has also reached in different experimental devices 2) \_\_\_\_\_\_\_\_\_at studying the possibility of producing energy in a controlled fashion.3) \_\_\_\_\_\_\_\_\_, fission is a nuclear process which does not normally occur in nature. The reason for this is that it requires a large mass and an incident 4) \_\_\_\_\_\_\_\_\_to initiate the process. But there have been 5) \_\_\_\_\_\_\_\_\_where nuclear fission has occurred in natural reactors.

If accidentally, a fission reactor goes out of control as a result of not controlling the emission of neutrons, a nuclear meltdown can happen which can the 6) \_\_\_\_\_\_\_\_\_highly radioactive particles in the atmosphere. In contrast, in case of nuclear fusion if the reactor goes out of control, the reaction would 7) \_\_\_\_\_\_\_\_\_automatically as it will cool down. In addition, in case of nuclear fusion reaction, the amount of radioactive materials produced as 8) \_\_\_\_\_\_\_\_\_is very small and the 9) \_\_\_\_\_\_\_\_\_damage which could happen is the 10) \_\_\_\_\_\_\_\_\_of anything in the immediate vicinity of the reaction.

1. A nuclear B hydrogen C neutron
2. A produced B tested C aimed
3. A on the other hand B moreover C although
4. A proton B electron C neutron
5. A incidents B accidents C examples
6. A release B absorb C collide
7. A continue B stop C change
8. A waste B energy C electricity
9. A minimum B maximum C average
10. A vaporization B freezing C heating

**11. Complete each sentence by matching it with the appropriate ending.**

|  |  |
| --- | --- |
| 1. At large distances two naked nuclei repel one another because 2. If two nuclei can be brought close enough together 3. When a nucleon such as a proton or neutron is added to a nucleus 4. Fusion power does not produce 5. Very few atoms are needed 6. At the high temperatures involved, controlling the scorching gases 7. Fusion power is not perfect and will | a) the nuclear force attracts it to other nucleons;  b) produce some radioactive by-products as neutrons are released in the main reactions.  c)is the main difficulty, so although fusion has been achieved these machines  only work for a few seconds at a time;  d) greenhouse gases;  e)of the repulsive electrostatic force between their positively charged protons;  f) to produce huge amounts of energy.  g) The electrostatic repulsion can be overcome by attractive nuclear force which is stronger at close distances. |

SPEAKING

**12. Choose a sentence which expresses the main idea of the text.**

* Fusion is a fundamental power source across the universe;
* It’s not easy to harness the enormous power of the stars;
* Fusion is the most efficient solution of the energy crisis.

**13. Answer the questions to the text.**

1. Why does fusion happen naturally only in extreme places?
2. Why is the strong nuclear force greater for small nuclei than for large ones?
3. What isotopes can be used for the simplest fusion reaction? Why?
4. Why is it difficult to generate power from fusion on Earth?

**14. Complete these sentences with information that reflects your personal views.**

1. The deuterium-tritium fusion reaction is the most promising for producing sustainable fusion power…
2. Research into controlled fusion is accompanied by extreme scientific and technological difficulties…
3. In order to be useful as a source of energy, a fusion reaction must satisfy several criteria…

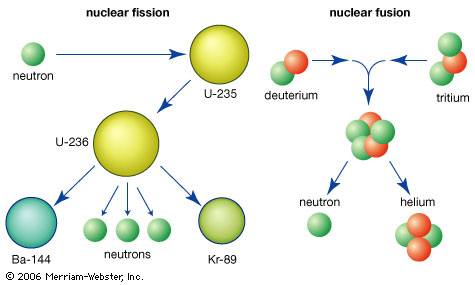
**15. Read the sentences and mark T (true) or F (false).**

1. In physics, nuclear fusion is the process by which multiple atomic particle are joint together to form a heavier nucleus.
2. It takes relatively little energy to force nuclei to fuse.
3. Whereas the fusion of heavy elements in stars releases energy, production of the lightest elements absorbs energy.
4. The energy released in most nuclear reactions is much larger than in chemical reactions.
5. The fusion of two nuclei lighter than iron generally absorbs energy while the fusion of nuclei heavier than iron releases energy.
6. Nuclear fusion occurs naturally in stars.
7. Reactions which are not self-sustaining can release considerable energy, as well as numbers f neutrons.
8. When the fusion reaction is a sustained uncontrolled chain, it can result in a thermonuclear explosion.

**16. Test yourself.**

1. What happens during nuclear fusion?
2. What reaction is considered the most promising for producing sustainable fusion power?
3. What elements have the largest binding energies per nucleon of all nuclei?
4. Does fusion only release energy, or it can absorb energy?
5. Where does fusion occur naturally?
6. Has artificial fusion in human enterprises achieved?
7. What process is called nucleosynthesis?
8. What scientific and technological difficulties the controlled fusion is accompanied by?
9. How can scientists overcome electromagnetic repulsion to achieve fusion?
10. Do fusion or fission reactions have a greater energy density per unit of mass?

**17. Look at the chart and describe it.**



**18. In pairs role-pay a conversation in which a scientist explains a layperson the necessity of further research into fusion.**

LISTENING

**19. Watch a video ‘Nuclear fission and nuclear fusion ‘. Finish the sentences or answer the questions.**

1. Nuclear fusion is…
2. It releases more energy than…
3. What happens during the reaction of nuclear fusion?
4. Why is it so important to harness the fusion power?

WRITING

**20. Translate the paragraph into Russian.**

Stardust

Stars are nature’s fusion reactors. Within stars, heavier elements are gradually built up in steps by fusion. Larger and larger nuclei are constructed through a succession of burning first hydrogen, then helium, then other elements lighter than iron and, eventually, elements heavier than iron. Stars like the Sun shine because they are mostly fusing hydrogen into helium and this proceeds slowly enough that heavy elements are made in only small quantities. In bigger stars this reaction is sped up by the involvement of the elements carbon, nitrogen and oxygen in further reactions. So more heavy elements are made more quickly. Once helium is present, carbon can be made from it. As soon as some carbon is made it can combine with helium to make oxygen, neon and magnesium. These slow transformations take most life of the star.

**21. Translate the paragraph into English.**

Радиационная безопасность

Термоядерный реактор намного безопаснее ядерного реактора в радиационном отношении. Прежде всего, количество находящихся в нем радиоактивных веществ сравнительно невелико. Энергия, которая может выделиться в результате какой-либо аварии, тоже мала и не может привести к разрушению реактора. При этом в конструкции реактора есть несколько естественных барьеров, препятствующих распространению радиоактивных веществ. Например, вакуумная камера и оболочка криостата должны быть герметичными, иначе реактор просто не будет работать. Для того, чтобы предотвратить распространение радиоактивных веществ, если они выйдут за пределы вакуумной камеры и криостата, необходима специальная система вентиляции, которая должна поддерживать в здании реактора пониженное давление. Поэтому из здания не будет утечек воздуха, кроме как через фильтры вентиляции.

**22. Write an article in which you can compare the properties and their strong and weak sides and express your opinion on the future possibilities to use these kinds of energy to get electricity.**

|  | **Nuclear Fission** | **Nuclear Fusion** |
| --- | --- | --- |
| Definition | Fission is the splitting of a large atom into two or more smaller ones. | Fusion is the fusing of two or more lighter atoms into a larger one. |
| Natural occurrence of the process | Fission reaction does not normally occur in nature. | Fusion occurs in stars, such as the sun. |
| Byproducts of the reaction | Fission produces many highly radioactive particles. | Few radioactive particles are produced by fusion reaction, but if a fission "trigger" is used, radioactive particles will result from that. |
| Conditions | Critical mass of the substance and high-speed neutrons are required. | High density, high temperature environment is required. |
| Energy Requirement | Takes little energy to split two atoms in a fission reaction. | Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion. |
| Energy Released | The energy released by fission is a million times greater than that released in chemical reactions, but lower than the energy released by nuclear fusion. | The energy released by fusion is three to four times greater than the energy released by fission. |
| Nuclear weapon | One class of nuclear weapon is a fission bomb, also known as an atomic bomb or atom bomb. | One class of nuclear weapon is the hydrogen bomb, which uses a fission reaction to "trigger" a fusion reaction. |
| Energy production | Fission is used in nuclear power plants. | Fusion is an experimental technology for producing power. |
| Fuel | Uranium is the primary fuel used in power plants. | Hydrogen isotopes (Deuterium and Tritium) are the primary fuel used in experimental fusion power plants. |

**How to Write a Scientific Article:**

**‘Cookbook’ for the Introduction, Methods and materials, Results, and Discussion Sections**

Consult this ’cookbook’ to get instructions for creating the four most difficult parts of the article so they will do what a scientific reader expects them to do. As you write, turn to the section you are working on and make sure it follows these instructions in the order they are given.

**INTRODUCTION**: The introduction answers the questions: what, why?, and how? (“who?”and where? and when? are identified on your title page by your name, course, and date.)

Teach the reader about your subject:

Define the subject, describing those characteristics of the structure, chemical, etc. you will study and explaining those characteristics’ importance. As you do, mention pertinent literature that discusses previous research on your subject.

Describe the controversy or question which requires you to perform this experiment, referring to the literature mentioned in (…)

State how your experiment addresses this question or controversy. (your purpose)

Finish with the major finding of your report, in one sentence if possible.

**MATERIALS AND METHODS**: This section describes the essential stages of the procedure necessary to reproduce this experiment.

Tell the reader how to repeat your experiment:

Explain the source of chemicals or something else.

Explain your ’experimental design’, including the number and types of substances, ,quantities and concentrations of chemicals, make and model of unusual equipment, essential conditions (heat/cold, time agitation or other stimuli)

Explain procedures used to measure effects you studied

**RESULTS**: the Results section reports, without conclusions or discussion, specific effects the MATERIALS AND METHODS said you were looking for.

Tell the reader what you found, dividing results of complicated experiments into types and reporting each type of result in a separate paragraph:

Open each results paragraph with one general sentence stating the part of procedure used to see the result described in that paragraph (should correlate with 3) in Materials and Methods)

List your results in tables or in clear figures. You MUST refer to every figure or table in the text.

**DISCUSSION**

In you discussion, you must ANALYZE and EXPLAIN your results.

Link your results to your original hypotheses.

Explain your experimental observations in specific terms.

Discuss possible sources of error and how they might have affected your results.

Compare your results to those of similar experiments published elsewhere.

Draw overall conclusions.

This is your chance to show us your capacity for creative, scientific thought. Refer to literature and other published material on the subject, but offer your own insights and ideas about your observations.

UNIT ONE. VOCABULARY LIST

|  |  |
| --- | --- |
| absorption n  bond ,v  boost, v  by-product, n  complementary, adj  conjugation, n  devastate, v  disrupt, v  emerge, v  emission, n  Enrich, v  envelop, v  equation, n  equivalence, n  exothermic, adj  fissile, adj  harness (v)  ignite, v  implement, v  infer (v) | infinitesimal, adj  leftover (n)  map (v)  mediate (v)  minuscule (adj)  multiplication (n)  parity (n)  perpendicular (adj)  proliferation (n)  purity (n)  replicate (v)  repulsive (adj)  seek (v)  self-sustaining (adj)  spontaneous (adj)  transmutation (n)  trigger (v)  undergo (v)  unleash (v)  vicinity (n) |

APPENDIX: Mathematical symbols in English

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Symbol** | **Name** | **Read as** | **Symbol** | **Name** | **Read as** |
| = | equality | equals, is equal to | ∏ | multiplication | product over … from … to …of |
| ≡ | definition | is defined as | ! | factorial | factorial |
| ≈ | approximately equal | is approximately equal to | ⇒ | material implication | implies |
| ≠ | inequation | does not equal, is not equal to | ⇔ | material equivalence | if and only if |
| < | strict inequality | is less than | |…| | absolute value | absolute value of |
| > |  | is greater than | || | parallel | is parallel to |
| ≪ |  | is much less than | ⊥ | perpendicular | is perpendicular to |
| ≫ |  | is much greater than | ≅ | congruence | is congruent to |
| ≤ | inequality | is less than or equal to | φ | golden ratio | golden ratio |
| ≥ |  | is greater than or equal to | ∞ | infinity | infinity |
| ∝ | proportionality | is proportional to | ∈ | set membership | is an element of |
| + | addition | plus | ∉ |  | is not an element of |
| - | subtraction | minus | {,} | Set brackets | the set of |
| × | multiplication | times | ℕ | Natural numbers | N |
| ∑ | summation | sum over … from … to … of, sigma | ℤ | Integers | Z |
| ÷ | division | divided by | ℚ | Rational numbers | Q |
| / | slash | over smth; divided by | ℝ | Real numbers | R |
| ± | plus-minus | plus or minus | ℂ | Complex numbers | C |
| ∓ | minus-plus | minus or plus | x̄ | Mean | bar, overbar |
| √ | square root | square root | x̄ | complex conjugate | the complex conjugate of x |

**GRAMMAR**

**THE INFINITIVE**

1. The infinitive can be the subject of the sentence, and translated as the infinitive or a noun.

*To be* a materialist means to accept the primacy of matter.

*To determine* the properties of the substance needs a lot of experiments.

1. As an object it the infinitive is used after the predicate.

They have *to minimize* the disadvantages.

1. The infinitive can be an adverbial modifier.

The form of the equation should be simple so as *to be* useful for the calculation.

1. As an attribute the infinitive is translated by a subordinate clause with the help of the following words: который, должен, нужно, можно.

There are many considerations *to be taken* into account in determining space velocity.

1. As a parenthesis the infinitive is usually used at the beginning of the sentence with a comma after it.

This is the list of most frequently used parentheses:

**to begin (start) with -** прежде всего;

**to judge by –** судя по, если судить по;

**to make a long story short** – короче говоря;

**to mention (only some)** – если упомянуть (лишь некоторые);

**to name (only a few) –** если упомянуть (лишь немногие);

**to put it another way** – иначе говоря;

**to put it briefly** – короче говоря;

**to put it mildly** – мягко выражаясь;

**needless to say** – нет надобности говорить о…;

**to say nothing of** - не говоря уже о… ;

**suffice it to say** – достаточно сказать;

**to be exact** – точнее говоря;

**so to speak** – так сказать;

**to sum up** – если подвести итог;

**to quote (a single example)** – если привести (один пример);

**to return** – если возвратиться;

**to tell the truth** – по правде говоря.

The to-infinitive is used:

1. To express purpose*. To live* long it is necessary to live slowly (M. T. Cicero)
2. After certain verbs (**advise, agree, appear, decide, expect, hope, manage, offer, promise, refuse, seem, want, afford**, etc.) They decided *to check* the new device.
3. After adjectives such as **nice, glad, afraid**, etc. It was very difficult *to do* the calculations on time.
4. After **too** and **enough** Physicists haven’t got enough data to understand this phenomenon.
5. After it + be +adjective (+ of + noun (pronoun) It is very important to discover any evidence for any graininess in gravity.
6. After **would like/ would love/would prefer** They would prefer to repeat the experiment in another mode.

The bare infinitive is used:

1. After modal verbs

*These vertices can be used to represent many different types of interactions.*

1. After the verbs **let, make, see, notice, hear and feel** but: be made/ be heard/ be seen + to +infinitive

*Feynman’s diagrams let physicists to calculate the probability that the interaction will take place.*

1. After **had better** and **would rather**

*We had better follow some basic rules.*

Note: if two infinitives are joined by ***and,*** the ***to***of the second infinitive can be omitted.

**Forms of the Infinitives**

|  |  |  |
| --- | --- | --- |
|  | Active Voice | Passive Voice |
| Present Simple | **( to) write** | **(to) be written** |
| Present Continuous | **(to) be writing** | **(to) be being written** |
| Present Perfect | **(to) have written** | **(to) have been written** |
| Perfect Continuous | **(to) have been writing** | **(to) have been being written \*** |

**The Present Infinitive refers to the present or future**. e.g. To construct an experiment of this kind seems nearly impossible.

**The Present Continuous Infinitive expresses an action happening now**. e.g. Physicists seem to be struggling with this discrepancy.

**The Perfect Infinitive** is used to show that the action of the infinitive happened before the action of the verb. e.g. They claim to have seen larger particles behaving like waves.

**The Perfect Continuous Infinitive** is used to emphasize the duration of the action of the infinitive, which happened before the action of the main verb. e.g. They seem to have been computing all night.

**The verb tenses corresponding to the tenses of the infinitive are the follows**

|  |  |
| --- | --- |
| **Verb tenses** | **infinitive** |
| He goes/will go | **To go** |
| He is going/will be going | **To be going** |
| He went/has gone/had gone/will have gone | **To have gone** |
| He was going/has been going/had been going/ | **To have been going** |
| He will have been going | **To have been going** |

Время, выраженное инфинитивом, носит относительный характер. **The Present Infinitive** выражает будущее действие или одновременное действие, выраженное сказуемым.

**The Continuous Infinitive** выражает действие длительного характера, одновременное с действием, выраженное сказуемым.

**The Perfect Infinitive** выражает действие, которое предшествует действию, выраженному сказуемым.

**The Perfect Continuous Infinitive** выражает действие, которое длилось в течение определенного периода времени до настоящего момента.

Перевод инфинитива на русский язык зависит от его функции в предложении. В роли подлежащего инфинитив стоит в начале предложения, перед сказуемым, и может переводиться неопределенной формой глагола, или существительным.

e.g**. To think** otherwise would be a mistake **Думать** по-другому было бы ошибкой.

**To account for** these variations is in principle simple**. Объяснение** этих изменений в принципе

простым.

В роли определения инфинитив обычно стоит после определяемого слова и обязательно переводится придаточным предложением, вводимым союзом **который**. При этом надо помнить, что инфинитив в форме Present infinitive можно переводить сказуемым в будущем времени и даже со словами **должен, нужно, можно**, независимо от времени сказуемого.

e.g. The curves **to be presented** in this Part were obtained on single- crystal samples.

Кривые, **которые будут представлены** в этой части, были получены на образцах монокристаллов.

В роли вводного члена инфинитив обычно стоит в начале предложения, всегда выделяется запятыми и может переводиться или деепричастием, или неопределенной формой глагола.

e.g. **To sum up**, we will present the table **Подводя итог (чтобы подвести итог)**,приведем таблицу.

При переводе инфинитива в роли вводного члена предложения иногда приходится использовать связующие слова типа **следует отметить, необходимо упомянуть** и т.п.

e.g. **To begin with**, no general method will be given here. **Для начала следует сказать**, что никакого общего метода здесь не будет дано.

EXERCISES

**1. Translate the sentences into Russian**.

1. To construct an experiment of this kind seems nearly impossible.
2. We attempted to carry out this investigation.
3. To perform this work one must have all the necessary equipment.
4. Rotation spectra can be used to measure bond lengths.
5. With these conditions there are also opposing factors to be considered.
6. It is too urgent a matter to be postponed.
7. Some molecules are large enough to be seen on the electron microscope.
8. Thomas was the first to focus attention on this type of reaction.
9. Two numbers –latitude and longitude, for instance are enough to fix your position.
10. The important thing is to understand what you are doing, rather than to get the right answer.

**2. Read the text and try to find infinitives in it and define its forms**.

Newton tried to understand the relationships between objects and movement by thinking about a spinning bucket of water. At first when the bucket is turned, the water stays still even though the bucket moves. Then the water starts to spin as well. Its surface dips as the liquid tries to escape by creeping up the sides but it is kept in place by the bucket’s confining force. Newton argued that the water’s rotation could only be understood if it can be seen in the fixed reference frame of absolute space, against its grid. We could tell if the bucket was spinning just by looking at it because we would see the forces at play on it producing the concave surface of the water.

**3. Change the sentences according to the model using *too* and the infinitive**.

*Example: The results are very numerous. They can’t be summarized in this paper.*

*The results are too numerous to be summarized in this paper.*

1. The particle is so small that it cannot be seen.
2. This hypothesis is so doubtful that it cannot be discussed in this review.
3. This phenomenon is so rare that it cannot be satisfactorily explained.
4. The theory is so extensive that it cannot be given here.
5. The classification is so complicated that it cannot be used in practice.
6. The experiment is carried out so carelessly that it cannot be considered valid.
7. This problem is so complex that it cannot be solved at present.
8. The theoretical analysis is so complicated that it cannot be tested by experiment.
9. The data are so contradictory that they cannot be relied upon.
10. The applications of electricity are so numerous that they cannot be considered in this article.

**4. Choose the correct form of the infinitive**.

1. The direction of the magnetic force is found \_\_\_\_\_ different at different parts of the Earth’s surface.

a) to have been; b) to be; c)to being

1. For this reason it is hard \_\_\_\_\_ optimistic about the future of radiation as a method of treatment.

a) To be enough; b) to have been; c) to be too

1. …the action of its weight we may suppose this point to be its centre of gravity.

a) Eliminating; b)To eliminate; c)To have eliminated

1. The Sun appears to be a ball of yellow light too bright\_\_\_\_\_ directly.

a) To be gazed at; b) to gaze at; c) being gazed at

1. The gamma rays proved\_\_\_\_\_ true waves like X-rays, but of much shorter wavelength.

a) To have been; b) to be; c) being;

1. The immediate objective of the Apollo was\_\_\_\_\_ a man on the Moon and bring him back alive.

a) to have landed; b) to be landed; c) to land;

1. The results appeared to be lacking precision. To get better results another method should\_\_\_\_\_

a) to be applied; b) be applied; c) have been applied;

1. This means that one of these levels must\_\_\_\_\_ lower energy than before splitting.

a) have had; b) have; c) to have;

1. It turned out that a giant eruption of hot gases had taken place that day at the surface of the Sun, and it must\_\_\_\_\_ responsible for the strong radio signals coming from the west.

a) have been; b) be; c) to be;

**5. Complete the sentences using the words in bold and an infinitive.**

*e.g. The results are so contradictory. They can’t be used in the article. (too)*

*The results are too contradictory to be used in the article.*

1) These experimental investigations were so complicated that the research team couldn’t get any results for a long time. (too)

2) Cohesive forces are very strong. They can keep the molecules in their places. (enough)

3) The calculations are accurate. They can be applied in further research (enough)

4) The idea isn’t clear. It can’t be formulated exactly. (enough)

5) The point is quite trivial. It doesn’t need to be mentioned (too).

6) The task is very difficult. It can’t be done without some preliminary work.(too)

7) Electron microscope is very powerful. It allows the tiniest particles to be observed. (enough)

8) The classification isn’t simple. It can’t be used in practice. (enough)

9) The measurements are very accurate. They contribute the necessary information. (enough)

10) Both methods are very doubtful. They don’t permit complete agreement with the theory. (too)

**6. (A) John Reeder is a young researcher. He is going to solve a scientific problem. Using the prompts given, say what he expects to do, as in the example.**

*e.g. He expects to recognize a problem.*

a) collect experimental facts or data;

b) analyze data;

c) set up a tentative hypothesis;

d) plan his own experiments;

e) analyze the results;

f) make some necessary calculations, graphs, tables;

g) modify the hypothesis.

**(B) John has finished the experiments. Things didn’t happen the way he expected them to. Look at the prompts above again and make sentences as in the example**.

*e.g. He expected to have recognized the problem.*

**7. Fill in the correct infinitive form.**

1) I think they obtained successful results. They must have obtained successful results.

2) I think Hooke contributed to many areas of science, from astronomy to biology, and even architecture. Hooke must…

3) I think physicists will need cleverer technology to reach colder temperatures. They may…

4) I think the reaction is going too quickly. The reaction must…

5) I think the energy of a moving object doesn’t depend only on the mass of the object. It can’t…

6) I think the results of the calculations were accurate. The results must…

7) I think speed and velocity are used to compute the kinetic energy. Speed and velocity must…

8) I think it is possible that they have been working on that project for a year. They may…

9) I think they have done a breakthrough in understanding the nature of black holes. They must…

10) I think I will be processing the obtained results when you finish your project. I may…

**8. Report these sentences using one of the verbs in brackets and an infinitive in a proper form.**

*e.g. Scientists think that Maxwell’s equations are the most important advance since the universal theory of gravitation.(prove)*

Maxwell’s equation **proved to be** the most important advance since the universal theory of gravitation

1. The astrophysicists predicted that the Sun initially had a metal-rich core. (might)
2. They are sure that hydrogen was originally in the score has now burnt out. (must)
3. Dr. G. R. Isaak reported that his team in Birmingham have also detected solar oscillations.

( claimed)

1. They think that the necessary technique has been developed. (hope)
2. The astrophysicists are studying gravitational red shifts in the solar system with this technique.

(must)

1. Dr. Hill has found the periods of the Sun oscillations. (claim)
2. Dr. G.R. Isaac has measured the solar oscillations. (prove)
3. They will provide a mechanism for removing energy from the core, lowering the expected neutrino flux. (might)
4. They suggested it. The Sun was formed from chemically inhomogeneous material.(may)
5. Albert Einstein demonstrated that mass is a very concentrated form of energy. (prove)

**9. Complete the sentences with the infinitive so that they are true for you**.

1. I have recently decided to…
2. I’m flexible, but one thing I refuse to do is…
3. Five years from now, I hope…
4. I’m satisfied that I can afford…
5. I’m sure I will manage…
6. I confess that one thing I tend to do is…
7. I hope …
8. I want…
9. I expect…

**10. Practice to use different infinitives after modal verbs**.

1. Должно быть, он…

He must be ill.

He must be staying in the lab.

He must have finished the computing.

He must have been working since 8 a. m.

Translate into English

1. Должно быть, он уже заполнил таблицу.
2. Возможно, он сейчас заполняет таблицу.
3. Должно быть, он заполняет таблицу после каждого считывания показаний приборов.
4. Возможно, он заполняет эту таблицу несколько часов.

**11 Answer the questions using the right form of the infinitive**.

1. Is the Sun producing a much lower or higher neutrino flux? (seem)
2. Did Richard Feynman watch the explosion of the nuclear bomb in Los Alamos? (claim)
3. Do photons carry information in electromagnetic interactions? (must)
4. Are the Higgs bosons more massive than other particles? (appear)
5. Is the photoelectric effect used today in solar panels? (must)
6. Does a light quantum transfer its entire energy to a single electron? (seem)
7. Are physicists still searching for a new theory to explain high temperature superconductivity? (tend)
8. Is a group of physicists trying to explain the pattern of fundamental particles by treating them as waves or a string? (expect)
9. Have scientists failed to reveal the true nature of the light? (might)
10. Did Einstein try to unify quantum theory and gravity? (expect)