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Problem: Calculate the energy corresponding to 1 u. Solution: If we look at the atomic mass of carbon we see that it's 12 u, that is, 12 grams of carbon-12 contain 6'023 1023 element atoms (not Avogadro). With a simple calculation, we can know the mass of the carbon-12 atom: 1 hour is the twelfth part of this mass, ie 1'66 10-27 kg. The energy corresponding to this mass may be known to einstein's equation: The energy equivalent of the most accurately calculated unit of atomic mass is 931 MeV: 1 in c2 (1 66054 × 10-27 kg) × (2,99792 × 108 m/s)2 × 1,49242 × 10 –10 kg (m/s)2 2 2 x 1,49242 × 10-10 J × (1 MeV / 1.60218 × 10-13 J) - 931.49 MeV Atomic molecular theory was established in the early 19th century. Dalton, Avogadro and Proust were its main architects. According to her, the mass is discontinuous, so the smallest part that can be obtained from the body is the molecule. Molecules, in turn, can be divided into smaller bodies called atoms; molecules in simple organs are suedia from atoms that equal each other, while molecules in composite bodies are suedia from atoms of two or more classes. He also stated that this theory that atoms were indivisible, directed at their name (atoms meant non-divisible, in Greek), and that all atoms of the same element were the same. Therefore, we can define the atom as the smallest and most electrically neutral part, which consists of a chemical element and can intervene in chemical reactions without losing its integrity. Today, more than 107 different chemical elements are known, some of which do not exist in nature and have been artificially obtained. A series of discoveries that took place in the last third of the last century and the first third of the present forced a revision of this atomic theory: mendeleiev's periodic law, theories of ionization and radioactivity resulted in Rutherford first and then Bohr and Heisenberg creating today's atomic model. According to this model, the atom is not indivisible, but consists of smaller elements, called elementary particles. In an atom, two parts can be considered: a central or atomic nucleus made up of protons and neutrons and an outer part or crust, formed by electrons (there are as many electrons in the crust as protons in the nuclei, so the atom is electrically neutral) that rotate around the nucleus in the effigy of planets that rotate around the sun. The radius of the atom is about 10-8 cm and the radius of the nucleus is 10-13 cm, indicating that the mass is almost completely empty. About particles We now know that atoms are not indivisible, but they are made of subatomar particles called elementary particles. These can be defined as simpler physical properties than the atomic nucleus and are considered to be the last component of matter. The three elementary particles that become part of the atom are: electron, proton and neutron. The electron has a mass of 9,11 × 10-31 kg (approximately 1/1800 by weight of a hydrogen atom) and a negative charge of 1,602 × 10-19 °C (this value is used as a unit in nuclear physics); the proton has a mass of 1,673 × 10-27 kg (approximately the mass of a hydrogen atom) and a positive charge equal to the absolute value of the electron charge; neutron weighs slightly less than a proton and lacks an electric charge. It is now known that proton and neutron are not fundamentally different, but there are two states of the same particle called the nucleus, so the neutron can disintegrate into a proton plus an electron without implying that the electron previously existed, but is formed at the time of decay. Similarly, the proton can be transformed into a neutron for which it is intended to emit a positive electron (positron). Another particle of great importance in nuclear physics is neutrinos, which, although not mass and load, have energy and a lot of movement. The existence of neutrinos was derived from theoretical considerations which made the existence of this particle necessary if certain subatomic processes were in accordance with the laws of physics. The study of cosmic radiation, as well as experiments on particle accelerators, have facilitated the verification of the existence of a much larger number of elementary particles, all of which have ephesible life, that is, they disintegrate into others; these particles were given the names of ions, tauons, mesons, hyperons. The number of elementary particles discovered to date is more than a hundred. It is also known that in addition to each particle there is a corresponding antiparticle, which has the same weight as her and the same load, but the opposite sign. This means that the antiproton is a particle of the same mass as the proton, but whose load is a negative unit; antievanone (called positron) is the same as a positive charge electron. Antiparticles have a very short lifespan, because when they hit particles, they are annulled by the release of energy. What are isotopes? The atomic species is defined by two integers: the number of protons in the nuclei and the total number of multiple neutron protons. The first, called atomic number, Z, defines the element to which the atom belongs; that is, regardless of the number of neutrons they have, all atoms that have protons are hydrogen atoms, all of which have eight protons are oxygen atoms, etc. A second number, called a serial number. A is the nearest whole number to the mass (expressed in atomic mass units) of the atom; this means that all atoms with an A equal to 2 have a mass of approximately 2 units of weight; those with an A equal to 235 have a mass of about 235 units of atomic mass. It happens that there are several atomic species or classes of atoms that have the same atomic number but have different mass numbers. This means that within each chemical element there are several atomic species that differ in their atomic mass. These types of the same element are called isotopes, the name that is referred to (iso: equal; birthmarks: space) to which these atoms occupy the same place in the periodic table of elements. For example, hydrogen has three isotopes: an isotope with A-1, called protium (which lacks neutrons); isotope with A-2 called deuterium (which has 1 neutron); and isotope with A-3, called a plague (which has 2 neutrons). Are nuclei and isotopes equivalent? Nucleid is a generic name that applies to all atoms that have the same atomic number and same sex number. Symbolically each nucleid is represented by ZAM, where M is a symbol of the chemical element to which it belongs, and A and Z are its most classic and atomic numbers. The two nuclei, which differ in number of the most common but have the same atomic number, are types of the same chemical element. These two nuclei are said to be isotopes of this element. According to these nucleic definitions, it refers to the consideration of each species in itself, whereas the concept of isotopes means a comparative relationship. In practice, however, this subtle semantic difference between the two words is often forgotten, and although it is not strict, the use of the isotope as synonymous with nucleid, but not vice versa. In this work, and in order to monitor the use, we will use an isotope with two meanings: isotope strictu sensu and nucleid. What is radioactivity? The radioactivity was discovered by French scientist Antoine Henri Becquerel in 1896. The discovery took place almost occasionally: Becquerel conducted research into the fluorescence of double uranium and potassium sulphate and found that uranium spontaneously emits mysterious radiation. This property of uranium - later you would see that there are other elements that have it - emit radiation without being previously excited, was called radioactivity. In the event that the led to a large number of research on the subject. Perhaps most important in terms of characterising other radioactive substances were those carried out by marriage, as well as the French, Pierre and Marie Curie, who discovered polonium and radio, both in 1898. The nature of emitted radiation and the phenomenon of radioactivity studied in England by Ernest Rutherford, principally, and Frederick Soddy. As a result, it soon became known that the emitted radiation could be three distinct classes called alpha, beta and gamma, and that at the end of the process the original radioactive atom was transformed into an atom of a different nature, i.e. the transmutation of one atomic species took place into another. It is also said (and this is contemporary terminology) that a radioactive atom has experienced decay. We now know that radioactivity is a nuclear reaction of spontaneous decomposition; this means that the unstable nuclei disintegrate into more stable cores than it does while emitting radiation. The child's core (which is the result of decay) may not be stable and then disintegrate into a third, which can continue the process until a stable nucleid is eventually reached. It says that successive nucleids in a set of decays form a radioactive series or a radioactive family. Radioactive all isotopes of elements with an atomic number equal to or greater than 84 (polonium is the first) and today radioactive isotopes of elements whose natural isotopes are stable are obtained in the laboratory; is the so-called artificial radioactivity. The first acquisition of a radioactive artificial isotope in the laboratory (i.e. the discovery of artificial radioactivity) was made in 1934 by Fréderic Joliot and Irene Curie, daughter of Curie's husbands. What types of radioactive decay? In studying the phenomenon of radioactivity, Rutherford found that radiation emitted by radioactive decay could be three classes: alpha, beta and gamma; In addition, neutron emissions should be considered. Alpha radiation (α) consists of the helium isotope 4 core, i.e. consists of corpuscular radiation in which each corpus is composed of two protons and two neutrons. This means that the atomic mass has 4 units and the electric charge has 2 positive units. These protons and neutrons were previously part of a nucleus that had disintegrated. Beta radiation (β) consists of electrons, which means that it is also corpuscular in nature, in which each nucleus has an atomic mass of approximately 1/1800 and 1 negative unit. Unlike the previous case, the emerging electron previously did not exist in the nucleus, but comes from the transformation of the neutron into a proton that is inside the nucleus, and an electron that is ejected. Subsequently, positive beta radiation was discovered, similar to beta, but positively charged. It consists of positrons from the transformation of proton into neutron. Gamma radiation (γ) is electromagnetic in nature, similar to ordinary light or X radiation, but with a much shorter wavelength. Therefore, it is undulating in nature, without resting matter and cargo. This radiation also did not exist in the nuclei before, but it is the energy that is emitted as a result of the energy reset of the nucleus. In spontaneous fission, as well as induced fission and other nuclear reactions, neutron radiation produced by these particles is produced with a mass of 1 unit of atomic mass and without load. Laws governing different types of decay were discovered by Soddy and Fajans. These laws are: In alpha decay, because two protons and two neutrons are emitted, the nucleid son has two protons less than the father, which means that he retreated two places in the periodic system and his mass dropped by four units. In negative beta decay, because the neutron transforms into a proton, the child atom has a proton more than the father, representing that the position progresses in the periodic system, and its atomic mass does not differ. Gamma emissions do not represent their own decay, but there is an accompanying radiation of alpha or beta radiation, decay of this type or deexcitation of nucleids that were at an energy level higher than normal in this nuclei (aroused nuclei). When disintegrating with neutron emissions, the nucleid son of fathers is an isotope, but has a smaller mass in one unit. What law governs the radioactive decay process? The decay of a radioactive body is a statistical process; this means that, taking into account a certain radioactive atom, we cannot know when its decay occurred, but if we accept a very large number of atoms of the same nucleid, we may know a law that, on average, monitors its entire decay. It turns out that the probability of the decay of a radioactive atom remains constant over time. This means that when a radioactive substance disintegrates, its amount, which does not disintegrate, decreases exponentially over time. It is called the half-decay period T, while it must elap on the amount of radioactive substances has been halved. The T value can range from very small fractions of a second (short-term isotopes) to millions of years (long-lived isotopes). What are ionizing radiation? The term radiation is generally used to refer to electromagnetic energy or material particles that spread from the emitting focus in space. This propagation, in the absence of fields that affect radiation, is equal (in the form of rays to which the name refers). Some radiations are able to produce charged particles (ions) because they pass through the mass, so they are called generic ionizing radiation. In some cases, radiation consists of charged particles that have sufficient kinetic energy to produce ions when colliding with atoms in their path (hence they are called direct ionizing radiation); in other cases, radiation consists of unqualified particles which may lead to the release of directly ionising particles, so they are called indirectly ionising radiation. The main ionizing radiations are: alpha, beta and gamma radiation, X-rays and neutrons. Of these, the first two are directly ionizing radiation and the others indirectly ionize. What are nuclear reactions? By analogy with chemical reactions, nuclear reactions are called nuclear reactions to interactions between atomic nuclei or between atomic nuclei and elementary particles; interactions between elementary particles are also included in the extension. The first nuclear reaction performed in the lab was carried out by Rutherford in 1919, bombing the isotope of 14 nitrogen with alpha particles. In response, the isotope 17 oxygen and proton are produced. Symbolically represented by the equation: 714N + 24He→817O+11H As in chemistry, spontaneous decomposition of an unstable molecule is considered the simplest chemical reaction (monomolecular reaction), radioactivity is the simplest type of nuclear reaction and it is the one that was first discovered. In other types of nuclear reactions, there are generally two nuclei or particles that react that trigger reaction products. Similar to what happens in a chemical reaction, to create a nuclear reaction it is usually necessary to notify the original system of activation energy. The reaction releases energy, which manifests itself in the form of kinetic energy from reaction products, sometimes accompanied by the production of gamma radiation. How is the nuclear response carried out? Nuclear reaction can be schematically represented and +X→Y+b, where X and Y are initial and end cores, and the particle is used as a projectile, and b is an emerging particle. In order to react, the particle must have enough energy to produce it. In the first nuclear reactions carried out in the laboratory, radioactive decay particles were used as projectiles. Later, so-called particle accelerators were built, where the necessary energy is obtained by the stump of electric or magnetic fields. A widely used criterion for classifying nuclear reactions is their definition on the basis of two incidents and emerging particles a and b. This means that there is talk of reactions (n, p) in which the particle event is a neutron and an emerging proton, etc. When accelerators did not yet exist, alpha radiation from radioactive decay was used as a projectile; Rutherford's work in the early decades of this century focused on such reactions. The design of particle accelerators has allowed the use of other laden projectibules, in particular protons. In 1934, the Italian physicist Enrico Fermi conceived the idea of using neutron as a projectile, and a group of researchers under his leadership systematically studied the reactions between neutrons and various elements of the periodic table. In one of these reactions, which takes place between uranium-235 and neutron, Otto Hahn discovered cleavage in the final days of 1938. Among the most important types of nuclear reactions we should quote: Dispersion: In them is a particle of the same nature as a projectile. Everything happens as if it is bounced off target, although no one could guarantee that the emerging particle is the same as the one that struck. When the total kinetic energy of the originating products is equal to the energy of the final reaction products, it is said to be an elastic dispersion. If, on the other hand, the total kinetic energy of the reaction products is less than the initial one, we will say that it is a non-patriotic dispersion. In this case, the difference between the two energies is absorbed by the target, which is enthusiastic. Capture: In this response, part of the incident is absorbed by the target without emerging particles, with the exception of gamma photons. Fissian: In this type of reaction, the heavy core usually breaks into two fragments, the sizes of which are of the same order of magnitude, which is accompanied by neutron emissions and gamma radiation, with the release of large amounts of energy. Although there are cases of spontaneous cleavage or splitting by capturing a photon, the reaction is usually caused by neutron capture. Nuclear: This is a reaction between two nuclei of light atoms in which the core of a heavier atom is produced, along with the release of elementary particles and a large amount of energy. The energy released in the Sun and in the stars comes from fusion reactions. What is a chain nuclear fission reaction? Nuclear fission is a reaction that occurs by bombing neutrons of certain nuclei called fissile nuclei. In fission, when the white nucleus is broken, several neutrons are released with energy equal to or greater than the energy of incident neutrons, allowing the neutrons that are produced to lead to the formation of new physiomes and those released into new ones, etc. This can ensure that once the reaction has begun, there is no need to continue bombing external neutrons, but that the response is maintained on its own. When the reaction has started, it is able to keep saying it's a chain reaction. According to this definition, a chain nuclear fission reaction is a process of gradual nuclear physios in which all or part of the neutrons released in each fission are formed as new physicistes, etc. In order to know under what conditions a chain nuclear fission reaction may occur, it is necessary to study the vicissituds that follow the neutrons produced in the fission. If we imagine a neutron reacting with the nucleus of uranium 235, it will result in its cleavage, a process in which it releases an average of 2.5 neutrons. Part of the produced neutrons will lead to new physiotherapists; the next part shall be absorbed by the nuclei of other elements present in the system without leading to the formation of physiologists; the last part escapes abroad. Without even causing new physiotherapists. If the number of neutrons in the first group is equal to the unit, a self-sufficient reaction is achieved with a constant number of physios per unit of time, since each neutron that originally produced cleavage will result in additional useful neutrons to continue the process. So they say the system is a critical set. If the number of neutrons useful for the production of new physiologists were higher than the unit, the number of physiologists per unit of time would accelerate and we would have a hyperchrytic set. If, on the other hand, it were less than unity, the reaction would decrease over time and eventually stop; set is called subchrtic. The set will be critical, hyperchrytic or subchristic depending on the relative proportion of neutrons in each of the three groups, which is a function of the concentration of U-235 atoms in the middle, the concentration and nature of the remaining and the relationship between the volume and surface of the medium in which the reaction is made. Where is the practical interest fisso exist? The fact that fission can lead to a chain nuclear fission reaction allows it to be preserved once it is ed, which means that stationary energy production can be achieved. The practical consequence is that fission is a nuclear reaction that can serve as a source of energy to meet society's energy needs. In the nuclear process, this is similar to what is happening with chemical combustion reactions, which also serve as energy sources, because once coal or oil is ignit, the reaction itself remains without the need for any external action. What is meant by nuclear fuel? Nuclear fuel is any material containing fissile cores and can be used in a reactor to develop a chain nuclear reaction. According to him, uranium is a nuclear fuel, as is uranium oxide. In the first case, we mean a chemical element, one of which isotopes are fissile; to a specific chemical compound containing such isotopes. We mean the fissile isotopes of those nucleids that can experience cleavage. It is necessary to specify the energy of neutrons which may cause isotope fissification; For example, the U-238 is not fissile thermal neutrons, but is fissilely fast neutrons, although with little active part. Normally, unless greater details are made, any nuclei that fissile as thermal and rapid neutrons are understood as a fissile isotope. The only fissile isotope that exists in nature is uranium-235. It is located at a ratio of 0.711% in natural uranium. There are other fissile isotopes that do not exist in nature, but can be obtained artificially. The main ones are: Uranus-233. It is obtained by capturing a neutron at the core of torio-232. The formed middle core undergoes two beta decays, resulting in the aforementioned U-233. Plutonium-239. Although its traces have been detected, it is not considered a natural isotope. It is formed in captivity of the neutron by the nucleus U-238, followed by two beta emissions. Smaller than the previous ones is plutonium-241. It is formed by the capture of a neutron in Pu-240, which in turn comes from the capture of a neutron at the core of Pu-239. What is meant by fertile material? There are certain nuclei of high atomic mass elements that react with neutrons, capture them and emit beta particles in circumstances where the final nucleid is fissile. These initial nucleids, which are not fissile with thermal neutrons, have a strong practical interest because, when introduced into a nuclear reactor, they serve as a raw material for obtaining nuclear fuel. They are called fertile nucleides and the material that contains them as fertile material. Torium-232 and uranium-238 are the two most important fertile isotopes. Therefore, torium and impoverished natural uranium are two prolific materials of greatest technical interest. Where is the practical interest of fusion? The practical interest of fusion lies in the amount of energy obtained and the abundance of atomic elements used, which gives it the character of inexhaustible energy. Fusion reactions use light atomic elements, generally hydrogen and its isotopes: deuterium and trémium. Deuterium abounds in seawater at a ratio of one atom per 6500 hydrogen. Moreover, since three-quarters of the Earth is covered with water, it can be said that the reserves are inexhaustible. The plague, although rare in nature, can be generated by nuclear reactions with neutrons and with two isotopes of lithium, a material, on the other hand, abundant in the Earth's crust (20 ppm) and in seawater (0.17 ppm). From an energy point of view, the fusion of deuterium contained in one litre of water obtains energy equivalent to that produced when 300 litres of petrol is incinerated. What is the current state of fusion investigations? Fusion is in such a state of development that its technological feasibility has not yet been demonstrated. This means that the energy spent on producing fusion reactions could not be restored in its entirety. Two lines of work have been developed to demonstrate this technological feasibility or energy gain equal to the unit: magnetic and inercial birth rates. Magnetic bond fusion uses magnetic fields to make plasma particles accelerate in trajectories around magnetic field lines to make them easier to react. There are currently four machines operating under the Tokamak concept: Euratom JET; TFTR from Princeton (USA), T-20 from Russia and JT-60 from Japan. The most comprehensive results to date were achieved at JET in November 1991, when they received a power of 1.7 MW; subsequently, in 1993, the TFTR reached up to 6 MW and reached temperatures of 30 millionoC. The most advanced magnetic childbirth project is ITER (International Thermonuclear) reactor), a prototype based on the Tokamak concept, which is expected to achieve an energy gain greater than the unit. The Cadarache (France) site has been selected as the headquarters of the ITER project. In inertial fusion of childbirth, the laser or particle beam is used to supply the energy needed to fusion small particles of deutetheria and thypia. Lasers that have the energy of several tens of kilojoules are currently available. In particular, the most important are: NOVA (40 kJ) by Lawrence Li-vermore National Laboratory (USA), GEKKO-XII (10 kJ), Osaka University (Japan), OMEGA (30 kJ) from the University of Rochester (USA), PHEBUS (3 kJ) from France and VOLCAN from the United Kingdom. In order to achieve technological feasibility, it will be necessary to increase its energy by a factor of 10. In this sense, livermore indicated the laboratory began the design and construction of the facility: nif (National Ignition Facility) with energy between 1.8 and 2.2 MJ. At the same time France is carrying out a similar project: megajoule laser, which with energy between 1.8 and 3.2 MJ will be installed in Bordeaux. Bordeaux.