Binding Energy Per Nucleon Graph

Abundance of the chemical elements Abundance is measured in one of three ways: by mass fraction (in commercial contexts often called weight fraction), by mole fraction (fraction of atoms by numerical count, or sometimes fraction of molecules in gases), or by volume fraction. Most abundance values in this article are given as mass fractions. Volume fraction is a common abundance measure in mixed gases such as planetary atmospheres, and is similar in value to molecular mole fraction for gas mixtures at relatively low densities and pressures, and ideal gas mixtures. is the most stable nuclide (in that it has the highest nuclear binding energy per nucleon) and can easily be "built up" from alpha particles (being a product The abundance of the chemical elements is a measure of the occurrences of the chemical elements relative to all other elements in a given environment 50de43db82

== Relationship to nickel-62 == 50de43db82 Nickel-62, a relatively rare isotope of nickel, has a higher nuclear binding energy per nucleon; this is consistent with having a higher mass-per-nucleon because nickel-62 has a greater proportion of neutrons, which are slightly more massive than protons. (See the nickel-62 article for more). Light elements undergoing nuclear fusion and heavy elements undergoing nuclear fission release energy as their nucleons bind more tightly, so 62Ni might be expected... 50de43db82

Helium-4 The energy of helium-4 nuclear binding per nucleon is stronger than in any of those elements (see nucleogenesis and binding energy), and thus no Helium-4 (4He) is a stable isotope of the element helium. boron). It is by far the more abundant of the two naturally occurring isotopes of helium, making up virtually all the helium on Earth. Its nucleus consists of two protons and two neutrons and is identical to an alpha particle 50de43db82

Atomic mass 9988381346(51) Atomic mass (ma or m) is the mass of a single atom. The atomic mass mostly comes from the combined mass of the protons and neutrons in the nucleus, with minor contributions from the electrons and nuclear binding energy. The atomic mass of atoms, ions, or atomic nuclei is slightly less than the sum of the masses of their constituent protons, neutrons, and electrons, due to mass defect (explained by mass–energy equivalence: E = mc2). are reduced, by the binding energies between the protons and neutrons. The ratio of atomic mass to mass number (number of nucleons) varies from 0 50de43db82

Nuclear shell model When adding nucleons (protons and neutrons) to a nucleus, there are certain points where the binding energy of the next nucleon is significantly In nuclear physics, atomic physics, and nuclear chemistry, the nuclear shell model utilizes the Pauli exclusion principle to model the structure of atomic nuclei in terms of energy levels. Gapon) in 1932. The first shell model was proposed by Dmitri Ivanenko (together with E. The model was developed in 1949 following independent work by several physicists, most notably Maria Goeppert Mayer and J. Hans D. stability. Jensen, who received the 1963 Nobel Prize in Physics for their contributions to this model, and Eugene Wigner, who received the Nobel Prize alongside them for his earlier foundational work on atomic nuclei 50de43db82

For heavy nuclides, it is an exothermic reaction which releases large amounts of energy both as electromagnetic radiation... 50de43db82 The nuclear shell model is partly analogous to the atomic shell model, which describes the arrangement of electrons in an atom, in that a filled shell results in better stability. When adding nucleons (protons and neutrons) to a nucleus, there are certain points where the binding energy of the next nucleon is significantly less than the last one. This observation that there are specific magic quantum numbers of nucleons (2, 8, 20, 28, 50, 82, and 126) that are more tightly bound than the following higher number is the origin of the shell model. 50de43db82 For elements lighter than iron on the periodic table, nuclear fusion releases energy. For iron, and for all of the heavier elements, nuclear fusion consumes energy. Chemical elements up to the iron peak are produced in ordinary stellar nucleosynthesis, with the alpha elements being particularly abundant. Some heavier elements are produced by less efficient processes such as the r-process and s-process. Elements with atomic numbers close to iron are produced in large quantities in supernovae due to explosive oxygen and silicon fusion, followed by radioactive decay of nuclei such as Nickel-56. On average, heavier elements are less abundant in the universe, but some of those near iron are comparatively more abundant than would be expected from this trend. 50de43db82 The high binding energy of nickel isotopes in general makes nickel an "end product" of many nuclear reactions (including neutron capture reactions) throughout the universe and accounts for the high relative abundance of nickel—although most nickel in space (and possibly produced by supernova explosions) is nickel-58 (the... 50de43db82 The abundance of chemical elements in the universe is dominated by the large amounts of hydrogen and helium which were produced during Big Bang nucleosynthesis. Remaining elements, making up only about 2% of the universe, were largely produced by supernova nucleosynthesis. Elements with even atomic numbers are generally more common than their neighbors in the periodic table, due to their favorable energetics of formation, described by the Oddo–Harkins rule. 50de43db82 == Properties == 50de43db82

Isotopes of nickel decay by β+β+ to 58 Fe with a half-life over 7×1020 years Highest binding energy per nucleon of all nuclides The known isotopes of nickel range in mass number Naturally occurring nickel (28Ni) consists of five stable isotopes; 58Ni, 60Ni, 61Ni, 62Ni and 64Ni; 58Ni is the most abundant at over 68%. This element also has 11 known meta states. All the other radioactive isotopes have half-lives of less than 60 hours and most of these have half-lives of less than 30 seconds. 26 radioisotopes have been characterized; the most stable are 59Ni with a half-life of 81,000 years, 63Ni with a half-life of 101 years, and 56Ni at 6. 075 days 50de43db82

The abundance of elements in the Sun and outer planets... 50de43db82 Of all nuclides, iron-56 has the lowest mass per nucleon. With a binding energy of 8.79 MeV per nucleon, iron-56 is one of the most tightly bound nuclei. 50de43db82

Iron-56 754% of the iron on Earth. mass per nucleon. 79 MeV per nucleon, iron-56 is one of the most tightly bound nuclei. With a binding energy of 8. The high nuclear binding energy for 56Fe Iron-56 (56Fe) is one of four stable isotopes of iron, and the most common, comprising about 91 50de43db82

== Occurrence == 50de43db82 Atomic mass is often measured in dalton (Da) (a.k.a. unified atomic mass unit (u)). One dalton is equal to +1/12 the mass of a carbon-12 atom in its natural state, given by the atomic mass constant mu = m(12C)/12 = 1 Da, where m(12C) is the atomic mass of carbon-12. Thus, the numerical value of the atomic mass of a nuclide when expressed in daltons is close to its mass number. 50de43db82 The shells for protons and neutrons... 50de43db82 == Binding energy == 50de43db82

Nuclear binding energy Nucleons are attracted to each other by the strong nuclear force. In this context it represents the energy of the nucleus relative to the energy of the constituent nucleons when they are infinitely far apart. In theoretical nuclear physics, the nuclear binding energy is considered a negative number. The binding energy for stable nuclei is always a positive number, as the nucleus must gain energy for the nucleons to move apart Nuclear binding energy in nuclear physics and nuclear engineering is the minimum energy that is required to fully disassemble the nucleus of one atom into its constituent protons and neutrons, known collectively as nucleons. collectively as nucleons. Both the experimental and theoretical views are equivalent, with slightly different emphasis on what the binding energy means. The binding energy for stable nuclei is always a positive number, as the nucleus must gain energy for the nucleons to move apart from each other 50de43db82

The relative isotopic mass (see section below) can be obtained by dividing the atomic mass ma of an isotope by the atomic mass constant mu, yielding a dimensionless value. Thus, the atomic mass of a carbon-12 atom m(12C) is 12 Da by definition, but the relative isotopic mass of a carbon-12 atom Ar(12C) is simply 12. The sum of relative isotopic masses of all atoms in a molecule is... 50de43db82 The high nuclear binding energy for 56Fe represents the point where further nuclear reactions become energetically unfavorable. Because of this, it is among the heaviest elements formed in stellar nucleosynthesis reactions in massive stars. These reactions fuse lighter elements like magnesium, silicon, and sulfur to form heavier elements. Among the heavier elements formed is 56Ni, which subsequently decays to 56Co and then 56Fe. 50de43db82

Nuclear fission estimate. The fission process often produces neutrons and gamma rays, and releases a very large amount of energy even by the energetic standards of radioactive decay. The free energy released by the fission of one uranium-235 atom is about 100 million times the energy released by burning one carbon atom in air to produce CO2. According to Lilley, "The binding energy of a nucleus B Nuclear fission is a reaction in which the nucleus of an atom splits into two or more smaller nuclei. Normally binding energy is referred to and plotted as average binding energy per nucleon 50de43db82

It has the highest binding energy per nucleon of any known nuclide (8.7945 MeV). It is often stated that 56Fe is the "most stable nucleus", but this is because 56Fe has the lowest mass per nucleon, not binding energy per nucleon, of all nuclides. The lower mass per nucleon of 56Fe is possible because 56Fe has 26/56 ≈ 46.43% protons, while 62Ni has only 28/62 ≈ 45.16% protons. Protons are less massive than neutrons, meaning that the larger fraction of protons in 56Fe lowers its mean mass per nucleon without changing its binding energy, which is by definition measured with respect to the actual mix of protons and neutrons in the nucleus (even though free neutrons are unstable.) In other words, nickel-62 can be said to have the 'least massive' protons and neutrons of any isotope. 50de43db82 Helium-4 makes up about one quarter of the ordinary matter in the universe by mass, with almost all of the rest being hydrogen. While nuclear fusion in stars also produces helium-4, most of the helium-4 in the Sun and in the universe is thought to have been produced during the Big Bang, known as "primordial helium". However, primordial helium-4 is largely absent from the Earth, having escaped during the high-temperature phase of Earth's formation. On Earth, most naturally occurring helium-4 is produced by the alpha decay of heavy elements in the Earth's crust, after the planet cooled and solidified. 50de43db82 The mass of an atomic nucleus is less than the sum of the individual masses of the free constituent protons and neutrons. The difference in mass can be calculated by the Einstein equation, E = mc2, where E is the nuclear binding energy, c is the speed of light, and m is the difference in mass. This "missing mass" is known as the mass defect, and represents the energy that was released when the nucleus... 50de43db82 Nuclear fission was discovered by chemists Otto Hahn and Fritz Strassmann and physicists Lise Meitner and Otto Robert Frisch. Hahn and Strassmann proved that a fission reaction had taken place on 19 December 1938, and Meitner and her nephew Frisch explained it theoretically in January 1939. Frisch named the process "fission" by analogy with biological fission of living cells. In their second publication on nuclear fission in February 1939, Hahn and Strassmann predicted the existence and liberation of additional neutrons during the fission process, opening up the possibility of a nuclear chain reaction by assembling a critical mass of fissile material. 50de43db82

Nickel-62 nickel, having 28 protons and 34 neutrons. It is often stated that 56 Nickel-62 is a stable isotope of nickel, having 28 protons and 34 neutrons. 7945 MeV). It has the highest binding energy per nucleon of any known nuclide (8 50de43db82

Iron peak A graph of the nuclear binding energy per nucleon for all the elements shows a sharp increase to a peak The iron peak is a local maximum in the vicinity of Fe (Cr, Mn, Fe, Co and Ni) on the graph of the abundances of the chemical elements in the Solar System. abundant than would be expected from this trend 50de43db82

== List of isotopes == 50de43db82

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