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How to find atomic mass of an atom

The Atom and Electromagnetic Radiation Fundamental Subatomic Particles Particle Symbol Charge Mass electron e- -1 0.0005486 amu proton p+ +1 1.007276 amu neutron no 0 1.008665 amu The number of protons, neutrons, and electrons in an atom can be determined from a set of simple rules. The number of protons in the nucleus of the atom is equal to the atomic number (Z). The number of electrons in a neutral atom is equal to the number of protons. The mass number of the atom (M) is equal to the sum of the number of protons and neutrons in the nucleus. The number of neutrons is equal to the difference between the mass number of the atom (M) and the atomic number (Z). Examples: Let's determine the number of protons, neutrons, and electrons in the following isotopes. The different isotopes of an element are identified by writing the mass number of the atom in the upper left corner of the symbol for the element. 12C, 13C, and 14C are isotopes of carbon (Z = 6) and therefore contain six protons. If the atoms are neutral, they also must contain six electrons. The only difference between these isotopes is the number of neutrons in the nucleus. 12C: 6 electrons, 6 protons, and 6 neutrons 13C: 6 electrons, 6 protons, and 7 neutrons 14C: 6 electrons, 6 protons, and 8 neutrons Electromagnetic Radiation Much of what is known about the structure of the electrons in an atom has been obtained by studying the interaction between matter and different forms of electromagnetic radiation. Electromagnetic radiation has some of the properties of both a particle and a wave. Particles have a definite mass and they occupy space. Waves have no mass and yet they carry energy as they travel through space. In addition to their ability to carry energy, waves have four other characteristic properties: speed, frequency, wavelength, and amplitude. The frequency (v) is the number of waves (or cycles) per unit of time. The frequency of a wave is reported in units of cycles per second (s-1) or hertz (Hz). The idealized drawing of a wave in the figure below illustrates the definitions of amplitude and wavelength. The wavelength (l) is the smallest distance between repeating points on the wave. The amplitude of the wave is the distance between the highest (or lowest) point on the wave and the center of gravity of the wave. If we measure the frequency (v) of a wave in cycles per second and the wavelength (l) in meters, the product of these two numbers has the units of meters per second. The product of the frequency (v) times the wavelength (l) of a wave is therefore the speed (s) at which the wave travels through space. vl = s Light and Other Forms of Electromagnetic Radiation Light is a wave with both electric and magnetic components. It is therefore a form of electromagnetic radiation. Visible light contains the narrow band of frequencies and wavelengths in the portion of the electro-magnetic spectrum that our eyes can detect. It includes radiation with wavelengths between about 400 nm (violet) and 700 nm (red). Because it is a wave, light is bent when it enters a glass prism. When white light is focused on a prism, the light rays of different wavelengths are bent by differing amounts and the light is transformed into a spectrum of colors. Starting from the side of the spectrum where the light is bent by the smallest angle, the colors are red, orange, yellow, green, blue, and violet. As we can see from the following diagram, the energy carried by light increases as we go from red to blue across the visible spectrum. Because the wavelength of electromagnetic radiation can be as long as 40 m or as short as 10-5 nm, the visible spectrum is only a small portion of the total range of electromagnetic radiation. The electromagnetic spectrum includes radio and TV waves, microwaves, infrared, visible light, ultraviolet, x-rays, g-rays, and cosmic rays, as shown in the figure above. These different forms of radiation all travel at the speed of light (c). They differ, however, in their frequencies and wavelengths. The product of the frequency times the wavelength of electromagnetic radiation is always equal to the speed of light. vl = c As a result, electromagnetic radiation that has a long wavelength has a low frequency, and radiation with a high frequency has a short wavelength. Chemical behavior is what originally led scientists to classify matter into various elements. Chemical behavior is the ability of an atom to combine with other atoms. In more technical terms, chemical behavior depends upon the type and number of the chemical bonds an atom can form with other atoms. In classroom kits for building models of molecules, atoms are usually represented by colored spheres with small holes for pegs and the bonds are represented by the small pegs that can connect the spheres. The number of peg holes signifies the maximum number of bonds an atom can form; different types of bonds may be represented by different types of pegs. Atoms that have the same number of peg holes may have similar chemical behavior. Thus, atoms that have identical chemical behavior are regarded as atoms of the same element. For example, an atom is labeled a "carbon atom" if it can form the same number, types, and configurations of bonds as other carbon atoms. Although the basics are simple to explain, how atoms bind to each other becomes very complex when studied in detail; new discoveries are still being made as new types of materials are formed.What is atomic number? An atom may be visualized as a miniature solar system, with a large central nucleus orbited by small electrons. The bonding capacity of an atom is determined by the electrons. For example, atoms that in their normal state have one electron are hydrogen atoms and will readily (and sometimes violently) bond with oxygen. This bonding capacity of hydrogen was the cause of the explosion of the airship Hindenburg in 1937. Atoms that in their normal state have two electrons are helium atoms, which will not bond with oxygen and would have been a better choice for filling the Hindenburg. We can pursue the question back one step further: What determines the number of electrons? The number of protons in the nucleus of the atom. Here, the analogy between an atom and the solar system breaks down. The force that holds the planets in their orbits is the gravitational attraction between the planets and the sun. However, in an atom what holds the electrons in their orbit is the electrical attraction between the electrons and the protons in the nucleus. The basic rule is that like charges repel and opposite charges attract. Although a proton has more mass than an electron, they both have the same amount of electrical charge, but opposite in kind. Scientists have designated electrons as having a negative charge and protons as having a positive charge. One positive proton can hold one negative electron in orbit. Thus, an atom with one proton in its nucleus normally will have one electron in orbit (and be labeled a hydrogen atom); an atom with ninety-four protons in its nucleus will normally have ninety-four electrons orbiting it (and be labeled a plutonium atom). The number of protons in a nucleus is called the atomic number and always equals the number of electrons in orbit about that nucleus (in a nonionized atom). Thus, all atoms that have the same number of protons--the atomic number--are atoms of the same element.What is atomic weight? The nuclei of atoms also contain neutrons, which help hold the nucleus together. A neutron has no electrical charge and is slightly more massive than a proton. Because a neutron can decay into a proton plus an electron (the essence of beta decay), it is sometimes helpful to think of a neutron as an electron and a proton blended together, although this is at best an oversimplification. Because a neutron has no charge, a neutron has no effect on the number of electrons orbiting the nucleus. However, because it is even more massive than a proton, a neutron can add significantly to the weight of an atom. The total weight of an atom is called the atomic weight. It is approximately equal to the number of protons and neutrons, with a little extra added by the electrons. The stability of the nucleus, and hence the atom's radioactivity, is heavily dependent upon the number of neutrons it contains.What notations are used to represent atomic number and weight? Each atom, therefore, can be assigned both an atomic number (the number of protons equals the number of electrons) and an atomic weight (approximately equaling the number of protons plus the number of neutrons). A normal helium atom, for example, has two protons and two neutrons in its nucleus, with two electrons in orbit. Its chemical behavior is determined by the atomic number 2 (the number of protons), which equals the normal number of electrons; the stability of its nucleus (that is, its radioactivity) varies with its atomic weight (approximately equal to the number of protons and neutrons). The most well-known form of plutonium, for example, has an atomic number of 94, since it has 94 protons, and with the 145 neutrons in its nucleus, an atomic weight of 239 (94 protons plus 145 neutrons). In World War II, its existence was highly classified. A code number was developed: the last digit of the atomic number (94) and the last digit of the atomic weight (239). Thus, in some of the early documents examined by the Advisory Committee, the term 49 refers to plutonium. Styles of notation vary, but usually isotopes are written as: atomic number Chemical abbreviation atomic weight or as atomic weight Chemical abbreviation Thus, the isotope of plutonium just discussed would be written as: 94Pu239 or as 239Pu Since the atomic weight is what is often the only item of interest, it might also be written simply as Pu-239, plutonium 239, or Pu239. Skip to content Trial ends in Get cutting-edge science videos from JoVE sent straight to your inbox every month. The atom calculator is a tool for calculating the atomic number and the mass number based on numbers of atom components - protons, neutrons, and electrons (or vice versa). In addition, you can define the charge of ions with known numbers of protons and electrons. This article will provide you with the definition of an atom, atom components, atomic number and mass number, as well as with a short step-by-step tutorial of how to calculate numbers of atom components. Atom is the smallest constituent unit of matter that retains the properties of an element. A typical atom consists of a nucleus and electron cloud. Atom components are positively-charged protons and electrically neutral neutrons in the nucleus and negatively-charged electrons orbiting this nucleus. Protons and neutrons are called nucleons. Atoms are electrically neutral because they possess an equal number of electrons and protons. However, when an atom has an unequal number of protons and electron, it has an electrical charge and they create ions. If an ion has more protons than electrons, it is positively charged and is called a cation. Conversely, if an ion has more electrons than electrons, it is negatively charged and is called an anion. Some atoms can split into smaller parts (lighter nuclei). If you want to know half lifetime, you can use Half Life Calculator in order to calculate the number of nuclei remaining after a certain time. Atom is uniquely identified with the atomic number (symbol Z). The atomic number is the number of protons present in the nucleus. In case of uncharged atoms, the atomic number is equal to the number of the electrons. In contrast, in ions, the number of electrons is the difference between the atomic number and the charge of ions. In cations, there are fewer electrons than protons, while in anions, there are more electrons than protons. The number of neutrons in a given element, however, can vary. The variants of the same chemical element with a different number of neutrons are called isotopes. Protons and neutrons determine the mass of an atom. Mass number (symbol A) is a sum of numbers of protons and neutrons.How to calculate atomic number, atomic mass and charge or numbers of protons, neutrons and electrons? - useful equations If you know atomic number (Z), atomic mass (A) and charge (z), you can calculate numbers of protons (p), neutrons (n) and electrons (e) by given mathematical equations (1-3): p = Z (1) n = A - Z (2) e = Z - z (3) On the other hand, if you know numbers of protons (p), neutrons (n) and electrons (e), you can calculate atomic number (Z), atomic mass (A) and charge (z) (equations (4-6)): Z = p (4) A = p + n (5) z = p - e (6) Choose your element. Let's assume that it is the atom of sodium (Na). The charge is 0. Find the atomic number (Z) and mass number (A). They are equal to 11 and 23, respectively. Calculate numbers of protons, neutrons, and electrons by using mathematical expressions (1-3): p = 11 n = 23 - 11 = 12 e = 11 - 0 = 11 4. Alternatively, you can also calculate the atomic number, atomic mass, and charge. 5. Choose your element. Let's assume that it is the sulfide anion. 6. Find the numbers of protons, neutrons, and electrons. They are equal to 16, 16 and 18, respectively. 7. Calculate atomic number, atomic mass, and charge by using mathematical expressions (4-6): Z = 16 A = 16 + 16 = 32 z = 16 - 18 = -2 Of course, you don't have to perform all of these calculations by hand! Type any three values into this atom calculator and watch it do all the work for you. You may be asked to calculate atomic mass in chemistry or physics. There is more than one way to find atomic mass. Which method you use depends on the information you're given. First, it's a good idea to understand what exactly, atomic mass means. Atomic mass is the sum of the masses of the protons, neutrons, and electrons in an atom, or the average mass, in a group of atoms. However, electrons have so much less mass than protons and neutrons that they don't factor into the calculation. So, the atomic mass is the sum of the masses of protons and neutrons. There are three ways to find atomic mass, depending on your situation. Which one to use depends on whether you have a single atom, a natural sample of the element, or simply need to know the standard value. The method used to find atomic mass depends on whether you're looking at a single atom, a natural sample, or a sample containing a known ratio of isotopes: 1) Look Up Atomic Mass on the Periodic Table If it's your first encounter with chemistry, your instructor will want you to learn how to use the periodic table to find the atomic mass (atomic weight) of an element. This number is usually given below an element's symbol. Look for the decimal number, which is a weighted average of the atomic masses of all the natural isotopes of an element. Example: If you are asked to give the atomic mass of carbon, you first need to know its element symbol, C. Look for C on the periodic table. One number is carbon's element number or atomic number. Atomic number increase as you go across the table. This is not the value you want. The atomic mass or atomic weight is the decimal number, The number of significant figures varies according to the table, but the value is around 12.01. This value on a periodic table is given in atomic mass units or amu, but for chemistry calculations, you usually write atomic mass in terms of grams per mole or g/mol. The atomic mass of carbon would be 12.01 grams per mole of carbon atoms. 2) Sum of Protons and Neutrons for a Single Atom To calculate the atomic mass of a single atom of an element, add up the mass of protons and neutrons. Example: Find the atomic mass of an isotope of carbon that has 7 neutrons. You can see from the periodic table that carbon has an atomic number of 6, which is its number of protons. The atomic mass of the atom is the mass of the protons plus the mass of the neutrons, 6 + 7, or 13. 3) Weighted Average for All Atoms of an Element The atomic mass of an element is a weighted average of all the element's isotopes based on their natural abundance. It is simple to calculate the atomic mass of an element with these steps. Typically, in these problems, you are provided with a list of isotopes with their mass and their natural abundance either as a decimal or percent value. Multiply each isotope's mass by its abundance. If your abundance is a percent, divide your answer by 100. Add these values together. The answer is the total atomic mass or atomic weight of the element. Example: You are given a sample containing 98% carbon-12 and 2% carbon-13. What is the relative atomic mass of the element? First, convert the percentages to decimal values by dividing each percentage by 100. The sample becomes 0.98 carbon-12 and 0.02 carbon-13. (Tip: You can check your math by making certain the decimals add up to 1. 0.98 + 0.02 = 1.00). Next, multiply the mass of each isotope by the proportion of the element in the sample: 0.98 x 12 = 11.760.02 x 13 = 0.26 For the final answer, add these together: 11.76 + 0.26 = 12.02 g/mol Advanced Note: This atomic mass is slightly higher than the value given in the periodic table for the element carbon. What does this tell you? The sample you were given to analyze contained more carbon-13 than average. You know this because your relative atomic mass is higher than the periodic table value, even though the periodic table number includes heavier isotopes, such as carbon-14. Also, note the numbers given on the periodic table apply to the Earth's crust/atmosphere and may have little bearing on the expected isotope ratio in the mantle or core or on other worlds. Over time, you may notice the atomic mass values listed for each element on the periodic table may change slightly. This happens when scientists revise the estimated isotope ratio in the crust. In modern periodic tables, sometimes a range of values is cited rather than a single atomic mass. Find More Worked Examples