1. Basic Atom

The **atom** is the smallest unit of matter that retains the chemical properties of an element. Atoms consist of a nucleus and orbital electrons. The **nucleus** is a heavy central mass with a positive charge. The nucleus accounts for most of the mass of an atom but is small in diameter compared to the overall size of the atom. Particles within the nucleus are known as **nucleons**. Outside the nucleus is a cloud of **electrons** - small, negatively charged particles that are attracted to the atom by the opposing charge of the nucleus (coulomb forces).

2. Protons and Neutrons (Nucleons)

The nucleus is composed of **protons** and **neutrons**. Protons have a positive (+ 1) charge with a mass of about 1.007 atomic mass units (1.673×10^{-24} grams). Neutrons are neutral, or uncharged. Neutrons have a mass slightly larger than the proton, about 1.008 atomic mass units (1.675×10^{-24} grams). Although the coulomb forces between protons in the nucleus tend to push the nucleus apart, the nucleus is held together by the strong nuclear force that operates at extremely short distances. The strong nuclear force is believed to result from attractions between even smaller particles (quarks) that compose the neutrons and protons.

3. Electrons

The charge of the electron (- 1) is equal in magnitude to the charge of the proton but is negative instead of positive. In an uncharged atom, the number of orbital electrons equals the number of protons within the nucleus. When the number of orbital electrons does not equal the number of protons in the nucleus, an overall imbalance of charge exists for the atom. A charged atom is known as an **ion**. Ions readily form chemical bonds with other ions of opposing charge.

Although electrons exist in a cloud around the nucleus, it is useful to describe this arrangement as a series of energy levels, called shells. Within each shell are subgroups of electrons, called orbits. An atom may have a number of possible energy states, which correspond to different arrangements of electrons in the shells.

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Electrons normally occupy the lowest energy levels in the atom, with successive shells and orbits filled in a complex manner. If an atom absorbs energy, an electron can move to a higher-energy shell. Electrons occupying higher energy levels can move back to vacancies in lower energy levels by releasing energy. When the energy release is small (such as for transitions between outer shells of an atom), the release occurs as visible or ultraviolet light. When the difference in energy levels is large (such as when an electron moves to an inner shell), an x-ray is emitted.

4. Atomic Number, and Atomic Mass Number

The number of protons in the nucleus of an atom is known as the **atomic number**, and is represented by the symbol **Z**. The number of protons in the nucleus determines the arrangement of the electron shells for that atom, which accounts for most chemical characteristics associated with the atom. Therefore, atoms are grouped into **elements** according to their atomic number. Each element is also represented by a chemical name.

The total number of protons and neutrons in the nucleus of an atom is called the **atomic mass number** (or, mass number). The symbol **A** is used to denote the atomic mass number. Since atoms do not have "fractions" of protons or neutrons, the atomic mass number is an integer.

The atomic mass number should not be confused with the atomic mass. **Atomic mass** describes the relative mass of the atom (including orbital electrons). The scale for atomic mass is fixed so that it equals 12.000 amu for an atom having 6 protons, 6 neutrons and 6 electrons. This atom (Carbon-12) also has an atomic mass number of 12. For all other atoms, the atomic mass and atomic mass numbers differ slightly in magnitude.

The number of neutrons in an atom is called the **neutron number** and is represented by the symbol **N**.

Table 1 illustrates the relation of A, Z and N for several atoms.

Table 1 – Examples of Z, N, and A

	Atomic No. Z (Protons)	***Neutron No. N (Neutrons)***	***Mass No. A (Nucleons)***
Hydrogen-1	**1**	**0**	**1**
Carbon-12	**6**	**6**	**12**
Iron-56	**26**	**30**	**56**

5. Nomenclature

Standard nomenclature is used to identify atoms of different types. The chemical symbol for the element is written with an upper left superscript before the symbol, indicating the mass number (A). A lower left subscript before the symbol indicates the atomic number (Z). This is illustrated by the examples from table 1:

Hydrogen-1 $^{1}{}_{1}H$

Carbon-12 $^{12}{}_{6}C$

Iron-56 $^{56}{}_{26}Fe$

Since both the atomic number and the chemical symbol uniquely identify the element, it is acceptable to omit the atomic number. The designation of an atom is often simply the chemical symbol followed by the atomic mass number, e.g. H-1, C-12, Fe-56.

6. **Nuclides, Isotopes, Isobars**

It is convenient to classify atoms by similarities with other atoms. The term **nuclide** is the most general term that describes an atom. Any atom can be referred to as a nuclide, without making any implications about element groupings or other properties of that atom.

As stated earlier, an element is a group of nuclides with the same number of protons. However, there can be different numbers of neutrons present in the nucleus for atoms of the same element. Atoms that have the same number of protons but different numbers of neutrons are called **isotopes** of that element. This is illustrated for the three isotopes of the element hydrogen:

Hydrogen-1 (1 proton, 0 neutrons, A=1) ${}^{1}_{1}H$

Hydrogen-2 (1 proton, 1 neutron, A=2) ${}^{2}_{1}H$

Hydrogen-3 (1 proton, 2 neutrons, A=3) ${}^{3}_{1}H$

Isobars are defined as nuclides having the same mass number (A) but different atomic numbers (Z). Example: I-131, Te-131 and Se-131 are isobars. This term is rarely used.

7. Energy Units

The energies involved for individual reactions at the atomic level are small compared to everyday electrical and mechanical processes requiring huge numbers of atoms. The unit of energy used most frequently in atomic physics is the **electron volt, or eV**. An electron volt is defined as the amount of energy acquired by an electron when it falls through a difference in potential of 1 volt.

The eV unit is often used with a multiplier, either keV or MeV; 1 keV is equal to 1,000 eV, (1 keV = 10^3 eV) and 1 MeV is equal to a million eV, (1 MeV = 10^6 eV).

If it were possible to instantly turn on a light bulb, 1 MeV of energy would operate a 100 watt light bulb for a duration of only 1.6 x 10^{-15} seconds. Most nuclear interactions involve tens of keV up to several MeV of energy.