

The atom

COMPOSITION OF ATOMS

The smallest part of an element is an atom. It used to be thought that atoms are indivisible but they can be broken down into many different sub-atomic particles. All atoms, with the exception of hydrogen, are made up of three fundamental sub-atomic particles – protons, neutrons, and electrons.

The hydrogen atom, the simplest atom of all, contains just one proton and one electron. The actual mass of a proton is 1.672×10^{-24} g but it is assigned a relative value of 1. The mass of a neutron is virtually identical and also has a relative mass of 1. Compared to a proton and a neutron an electron has negligible mass with a relative mass of only $\frac{1}{1840}$. Neutrons are neutral particles. An electron has a charge of 1.602×10^{-19} coulombs which is assigned a relative value of -1 . A proton carries the same charge as an electron but of an opposite sign so has a relative value of $+1$. All atoms are neutral so must contain equal numbers of protons and electrons.

SUMMARY OF RELATIVE MASS AND CHARGE

Particle	Relative mass	Relative charge
proton	1	+1
neutron	1	0
electron	$\frac{1}{1840}$	-1

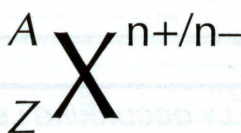
SIZE AND STRUCTURE OF ATOMS

Atoms have a radius in the order of 10^{-10} m. Almost all of the mass of an atom is concentrated in the nucleus which has a very small radius in the order of 10^{-14} m. All the protons and neutrons (collectively called nucleons) are located in the nucleus. The electrons are to be found in energy levels or shells surrounding the nucleus. Much of the atom is empty space.

MASS NUMBER A

Equal to the number of protons and neutrons in the nucleus.

SHORTHAND NOTATION FOR AN ATOM OR ION



ATOMIC NUMBER Z

Equal to the number of protons in the nucleus and to the number of electrons in the atom. The atomic number defines which element the atom belongs to and consequently its position in the Periodic Table.

CHARGE

Atoms have no charge so $n = 0$ and this is left blank. However by losing one or more electrons atoms become positive ions, or by gaining one or more electrons atoms form negative ions.

EXAMPLES

Symbol	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
${}^9_4\text{Be}$	4	9	4	5	4
${}^{40}_{20}\text{Ca}^{2+}$	20	40	20	20	18
${}^{37}_{17}\text{Cl}^-$	17	37	17	20	18

ISOTOPES

All atoms of the same element must contain the same number of protons, however they may contain a different number of neutrons. Such atoms are known as isotopes. Chemical properties are related to the number of electrons so isotopes of the same element have identical chemical properties. Since their mass is different their physical properties such as density and boiling point are different.

Examples of isotopes: ${}^1_1\text{H}$ ${}^2_1\text{H}$ ${}^3_1\text{H}$ ${}^{12}_6\text{C}$ ${}^{14}_6\text{C}$ ${}^{35}_{17}\text{Cl}$ ${}^{37}_{17}\text{Cl}$.

RELATIVE ATOMIC MASS

The two isotopes of chlorine occur in the ratio of 3:1. That is, naturally occurring chlorine contains 75% ${}^{35}_{17}\text{Cl}$ and 25% ${}^{37}_{17}\text{Cl}$. The weighted mean molar mass is thus:

$$\frac{(75 \times 35) + (25 \times 37)}{100} = 35.5 \text{ g mol}^{-1}$$

and the relative atomic mass is 35.5. Accurate values to 2 d.p. for all the relative atomic masses of the elements are given in Table 5 of the IB Data Booklet. These are the values which must be used when performing calculations in the examinations.