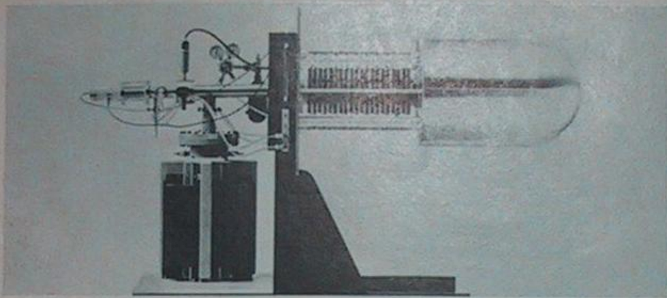
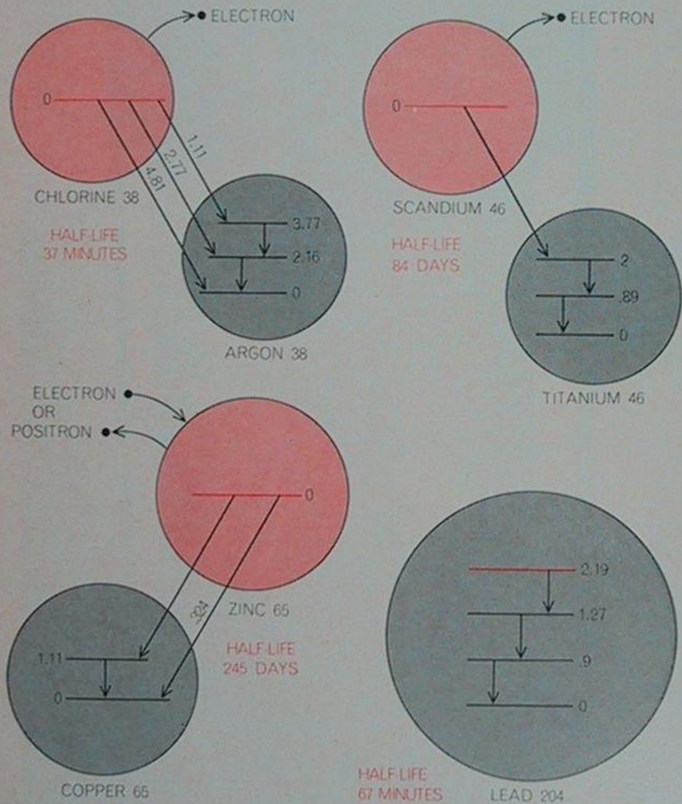


COCKCROFT-WALTON GENERATOR produces neutrons by bombarding a target (*inside end of tube at left*) with accelerated charged particles. The sample is placed in the path of the neutrons, which are emitted in all directions. Neutron generators produce a usable neutron flux about 10,000 times smaller than flux available from a nuclear reactor.



DECAY PROPERTIES of every radionuclide are unique to that particular nuclear species. An artificial radioactive nucleus usually decays by emitting electrons, positrons or gamma rays, or by absorbing an orbital electron. In each case the radioactive nucleus (*color*) loses internal energy, forming a more stable nucleus (*gray*), which can have the same atomic number (*arrows pointing straight down*), a higher atomic number (*arrows pointing to lower right*) or a lower atomic number (*arrows pointing to lower left*). A radioactive species can decay by a number of routes, sometimes producing a more stable species that is in an excited state. When the excited species decays to its ground state, it emits a gamma ray, which is usually associated with the decay processes of the parent radionuclide. Black numbers denote energy in millions of electron volts (MeV). Half-lives are indicated in color.

reacting isotopes, the cross section of the production reaction and the half-life of the radionuclide) and those factors that can be varied by the analyst (the neutron flux, the period of irradiation and the decay time prior to measurement of the induced activity). All these factors are expressed in a single mathematical equation called the activation equation.

There are three types of neutron source used for activating samples: nuclear reactors, neutron generators and isotopic sources. The neutron flux available in nuclear reactors allows analyses of most elements in concentrations from 10^{-12} to 10^{-6} gram. Neutron generators, such as the Cockcroft-Walton generator and the Van de Graaff generator, produce a usable flux about 10,000 times smaller than the flux available from a nuclear reactor, and this reduction in flux is accompanied by a comparable reduction in the sensitivity of measurement. The neutron yield of the isotopic sources is still lower, and they are used mainly to demonstrate the principles of the activation technique.

Since many different radionuclides are produced in a particular irradiated sample, the problem is to measure the activity of the indicator radionuclide in the presence of all the other induced radionuclides. This task is not as difficult as it sounds. It happens that every radionuclide disintegrates in a manner unique to itself. There are 66 natural radionuclides and 1,095 known radionuclides that can be artificially produced. No two of these 1,161 nuclei have exactly the same decay properties. Accordingly by measuring the decay properties of the radiation from a sample one can sometimes effectively isolate one radionuclide from all the others in the sample. When the decay properties cannot be measured directly, the radionuclides can be separated chemically. Therefore by one method or another all the activated nuclei in a sample can be identified and measured.

The radionuclides most frequently encountered in neutron-activation analysis decay by the emission of beta particles (electrons and positrons) and gamma rays. Because it is difficult to resolve beta-particle spectra resulting from mixtures of radionuclides, beta particles are not used for analysis unless they are the only emission from the indicator isotope, or unless the element can be conveniently isolated in a pure form. Gamma rays, on the other hand, are emitted with distinct energies that can be resolved by the standard technique known as scintilla-