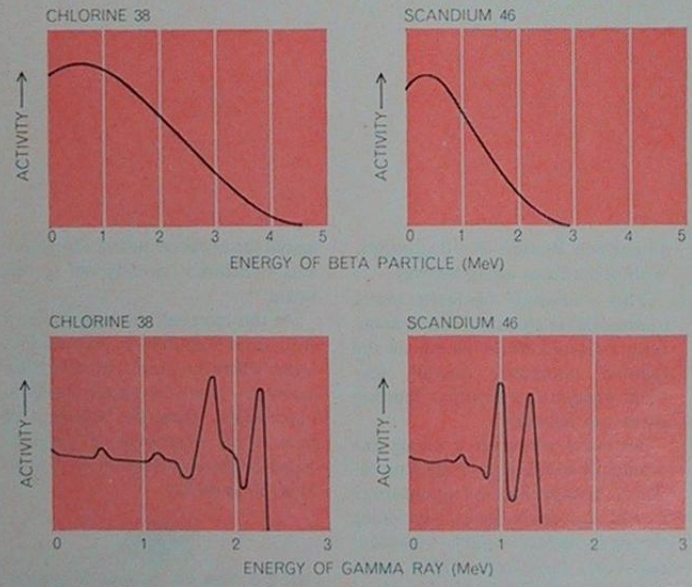
tion spectrometry; as a result most neutron-activation analyses are based on gamma ray data.

In scintillation spectrometry gamma rays are detected by causing them to interact with a material that responds to the interaction by scintillating, that is, by emitting photons of visible light whose intensity is directly proportional to the energy of the absorbed gamma ray. The most widely used scintillating material is a single crystal of sodium iodide "doped" with a small amount of the element thallium. The crystal is coupled to a photomultiplier tube, which detects the light emissions and converts them into electronic pulses. These pulses are fed into a multichannel pulse-height analyzer, which sorts them according to amplitude and counts the number of pulses in each amplitude range during a given counting period. The result is a record of the energy distribution of the gamma rays emitted by the radioactive nuclei in the sample.

In some cases the gamma rays emitted by different radionuclides are so similar in energy that they cannot be adequately resolved in the gamma ray spectrum. In these instances the different characteristic decay rates of the individual radionuclides can be used to isolate one isotope from another. It is often possible to maximize or minimize the activity of one radionuclide with respect to another in an activated sample by properly adjusting the duration of the irradiation period and the decay period. The use of time as an independent variable is unique to the neutron-activation technique, giving the analyst two additional factors to manipulate to his advantage. The ability to discriminate in this manner depends primarily on the difference in the half-lives of the radionuclides induced in the samples. Short irradiation periods are used to maximize the ratio of short-lived nuclei with respect to longer-lived nuclei when the longer-lived ones may give rise to interfering radiations. By the same token longer irradiation periods are employed to maximize the long-lived nuclei, and the analyses for these nuclei are completed after the short-lived nuclei have been allowed to decay.

When the radioactivity of the indicator nuclide cannot be accurately measured in the presence of other radionuclides, even after the time variables are taken into account, chemical methods are used to isolate the individual radionuclides. This situation usually obtains when the radiations from the desired indicator nuclide are effectively masked by more abundant radiations from longer-lived nuclei and cannot be resolved by spectral analysis. Even though the element of interest may be present in extremely small quantity, the methods of chemical separation are the same as those used in normal quantitative analyses. Instead of the separations' being carried out on a microscale, however, they are facilitated by the addition of a known amount (approximately 10 to 50 milligrams) of the element of interest to the sample after it has been irradiated, and then the chemical isolation of a mixture containing the radionuclide induced in the sample and the added stable element. The analysis is completed by the measurement of the radioactivity in the isolated mixture. Since the quantity of the added element is known, the efficiency of the chemical separation is easily determined, and the radioactivity measurements can be corrected for any losses caused by chemical processing after irradiation. Since the radiochemical separation need not be quantitative, the separation procedures can be shortened and the tedious work frequently required for quantitative analysis can be minimized.

Once the radiations of the indicator nuclide are isolated, quantitative measurements of the induced activity can be made. In principle the activation technique is an absolute analytic method, and the weight of an element can be determined directly from the measured activity and a knowledge of the nuclear constants and experimental conditions. But since it is difficult to make an absolute measurement of radioactivity, and because reaction cross section and neutron flux are seldom known precisely, activation analyses are not normally completed by the absolute method. Instead a comparative method is almost always used. A standard sample containing a known amount of the element to be analyzed is irradiated and processed in the same way as the sample being analyzed. Since all the terms in the activation equation except for the number of target atoms and the induced activity are the same for the control and the test sample, the activity of the indicator nuclide in the test sample can be directly compared with the activity of the control to obtain the weight ratio of the desired element in two samples. Analyses by this method can be completed with an accuracy of about 2 percent of the actual



MOST RADIONUCLIDES DECAY by emitting beta particles (electrons and positrons) or gamma rays. The beta-particle spectra of low-energy beta-particle emitters (*top*) are difficult to resolve in the presence of high-energy emitters; as a consequence beta particles are rarely used for neutron-activation analysis. Gamma rays, on the other hand, are emitted with distinct energies that can be readily resolved by scintillation spectrometry (*see illustration on opposite page*); as a result most neutron-activation analyses use gamma ray data.