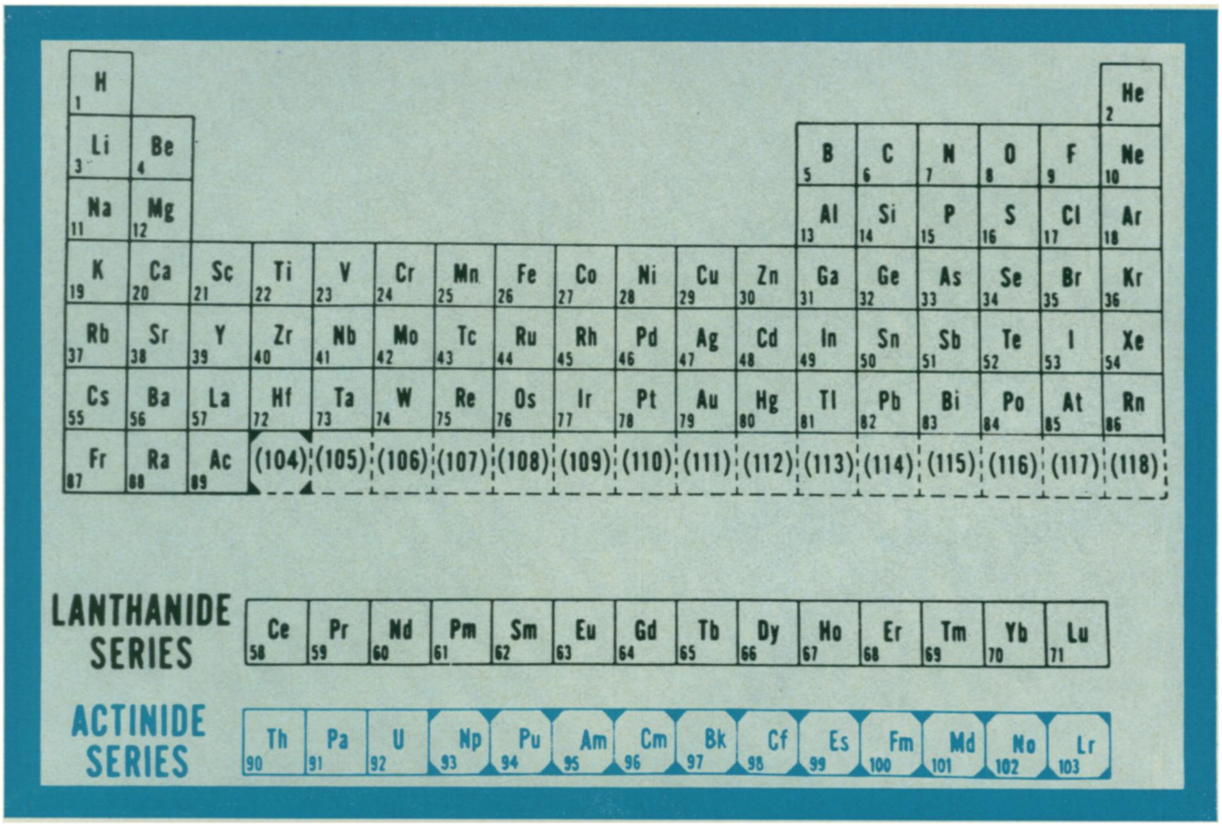

Seaborg

Evidence justifies a complete actinide series in the latest periodic table of the elements.

Solving the nobelium puzzle

Experiments nail down nobelium as a two-valence actinide, settling several of chemistry's international controversies

For years it has been theorized that the last 14 elements discovered, from thorium to lawrencium, belonged to a single series with similar chemical properties.

The primary characteristic of the actinide series, as it is called, is that all the elements belonging to it should have a valence of plus three; that is, in forming chemical compounds, they tend to lose three electrons. The single exception is nobelium, element 102, which should have a valence of two.

These theoretical predictions had never been verified, since the elements in question are so short-lived. But in just-completed experiments, reported to the American Chemical Society in San Francisco, Dr. R. J. Silva of the University of California, Berkeley, and Dr. E. K. Hulet of Livermore Radiation Laboratory, and others, have finally verified what had been assumed—the actinides belong in a group and their electrons are arranged in shells the way the theory says they are.

To Dr. Glenn T. Seaborg, chairman of the Atomic Energy Commission and pioneer discoverer of plutonium and many other actinide elements, the experiments were "very exciting . . . particularly gratifying to me because they support predictions made on the actinide concept."

The periodic table has long since differed from the simple systematic arrangement that Dmitri Mendeleev worked out in the 19th century. Packing of electrons into inner orbits, transition elements, and extraneous series all complicate the picture. The actinides, like the rare earth lanthanide series, are embarrassing footnotes to the smooth sequence of numbers.

But the table has a regularity of sorts.

In the actinide series, actinium, element 89, has a valence of three, caused by two loose electrons in what is called the 7S ring, and one in the 6D ring. But thorium, the next element, instead of adding another electron to the 6D ring, starts a new shell, the 5F ring. This shell can hold up to 14 electrons, and as the actinide elements move up the table, they push their additional electrons into that orbit.

As long as electrons are added into the 5F ring, the elements continue to have a valence of plus three, since electrons in the 5F ring aren't easily detached. But at element 102, nobelium, the 5F ring has 13 electrons, only one less than its full share. Going by past experience, chemists felt there should be a strong urge on the part of nobelium to fill that 5F ring, taking an electron from the 6D orbit. If that happened, there would only be two electrons left in a valence orbit; nobelium ought to be plus two instead of plus three.

And that's just what Dr. Silva and his colleagues discovered. The analysis was made using what Dr. Silva deprecatingly describes as standard, classical chemical methods, made unique by the remarkable speed that the short-lived elements required. Because they decayed so quickly, only a few atoms of the element could be picked up in a single test; the experiments had to be run hundreds of times.

One of the tests run at the California laboratory depended on the fact that a plus-three actinide is insoluble in ammonium chloride, while a plus two is soluble. Mixing traces of nobelium in ammonium chloride solution, the experimenters hooked up a five-volt battery to a platinum wire dipped in the solution and a platinum plate at the bottom of the solution container.

If the nobelium was insoluble, as it would be if it were plus three, the voltage would tend to deposit it on the platinum plate. If it were plus two, it would be in solution and would not be deposited on the plate.

Measuring on the plate for radioactivity of the particular kind emitted by nobelium, the experimenters found very little. They conclude that, unlike all the other actinides, nobelium does not have a plus-three valence; the conclusion was confirmed by other experiments of a similar nature.

The nobelium used in these experiments was obtained by bombarding plutonium 244 with oxygen ions accelerated to 160 million electron volts.

Moving up the scale, the experimenters produced lawrencium 256, an isotope with a half-life of 30 seconds, by bombarding californium 249 with boron 11 atoms. Running the same kind of chemical experiments, they found that this time the actinide had a valence of plus three. What happens is clear, says Dr. Silva. With the 5F ring filled to capacity, the next electron is free to move back into the valence position in the 6D ring.

The results on nobelium were startling, because the element appears so completely to take the plus-two valence.

"We expected to get some plus-two observations," says Dr. Silva, "but not the overwhelming proportions we did get."

The experiment also makes clear just who first discovered nobelium, a controversy that raged for 10 years before being settled by a compromise last year (SN: 9/16/67 p. 274). A European team claimed to have synthesized the element, but scientists at Berkeley later challenged their method.

"The Europeans based their claim on having found a radioactive plus-three element," supposing that nobelium, like the other actinides, had that valence, says Dr. Silva. "But our experiments show that if they got a plus-three actinide, it wasn't nobelium."

Because of the nobelium brou-ha-ha, the international committee that confirms discoveries of new elements hasn't yet acted on Russian claims to have synthesized element 104.

"They're a little gun-shy, I guess," says Dr. Silva. When it is discovered, scientists expect it to have a valence of four, like hafnium, element 72.

But because the higher number elements should be even more short-lived than nobelium and lawrencium, the classical chemistry used in the present experiments probably won't work. Some new detection means will have to be devised.

SCIENCE TEACHERS

Changes: slow, experimental, overdue

NEA/Joe Di Dio

A far cry from collecting tadpoles: Schools experiment with new curricula.

For at least 70 years educators have been arguing that children would learn better by doing things than by being told things. Last week in Washington the message was still: Change the medium.

As some 8,000 science teachers gathered at the annual convention of the National Science Teachers Association, their leaders and lecturers decried the traditional means of teaching science, which have been aimed more at producing professionals in the various fields than at making whole populations scientifically literate.

Since a program aimed that broadly should begin early, attention was focused on elementary education. The last decade has seen a number of efforts to reform elementary science curricula; the basic idea seems to be replacing lectures by the teacher with student activity. But the activity demanded by the new curricula is not the sort that has been done for years past, such as planting beans or collecting tadpoles. Rather it seeks to encourage the pupils to view a natural situation the way a scientist would, to reason in a scientific manner, and to elucidate for themselves basic principles that underlie the details of different disciplines.

For example, Prof. Morris H. Shamos, president of the association, reports that he achieved a good deal of success in presenting to middle elementary school children a series of lessons from a curriculum reform project he