CHAPTER THIRTEEN

FERMIUM, MENDELEVIUM, NOBELIUM, AND LAWRENCIUM

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13.1 GENERAL

Because of conflicting claims, the International Union of Pure and Applied Chemistry (IUPAC) recently reviewed the names of all the trans-fermium elements; Münzenberg (1999) has published a detailed discussion of the problems and the resolution. First, a Transfermium Working Group decided the priority of discoveries. Next, the discoverers proposed names to the IUPAC and names were officially accepted by that body. The names for the elements mendelevium, nobelium, and lawrencium were retained as originally proposed at the time of their discoveries.

As of this writing, the number of known isotopes of Fm, Md, No, and Lr is 58, ranging in half-life from as short as 0.25 ms for ^{250}No to as long as 100.5 days for ^{257}Fm. Relativistic effects have been predicted to affect ground state electronic configurations, ionic radii, and oxidation state for the heavier actinides. While the 3þ oxidation state remains a dominant feature of the heavier actinides, a tendency toward the formation of lower oxidation states has emerged. Divalency had been observed in solution for fermium through nobelium, in fact, the elements Fm, Md, and No are divalent in the metallic state. Due to increased 5f electron binding of the filled $5f^{14}$ shell, the 2þ oxidation state is the most stable in aqueous solution for nobelium. However, lawrencium, the last member of the actinide series, returns to the 3þ oxidation state as the most stable in aqueous solution, as predicted (Seaborg, 1949).

Due to the short half-lives and low production yields of Fm–Lr, all available chemical information has been obtained from experiments with tracer quantities. In fact, in many cases, chemical experiments were performed with only a few atoms or even one atom at a time. These experiments have necessarily been rather simple in principle, aimed primarily at making comparative studies with elements of known chemical properties. Nevertheless, all available experimental and theoretical evidence supports the original prediction of an actinide series (Seaborg, 1945) involving filling of the 5f electron shell, analogous to the lanthanide series resulting from the filling of the 4f electron shell, and that element 103 is the last member of this series of elements (Seaborg, 1949). The next element, atomic number 104, would be expected to fall into the next chemical group, i.e. Group IVB, of the periodic table.

13.2 FERMIUM

13.2.1 Introduction

The first isotope of element 100 was discovered in heavy-element samples obtained after the 'Mike' thermonuclear explosion of 1952, during the same set of experiments that resulted in the discovery of element 99. A joint effort by the researchers from the Lawrence Berkeley National Laboratory, the Argonne National Laboratory, and the Los Alamos National Laboratory resulted in the chemical isolation and identification of the 20 h half-life isotope ^{255}Fm (Ghiorso *et al.*, 1955a). The production involved rapid, multiple neutron capture by uranium nuclei in the nuclear device to form neutron-rich uranium isotopes of heavy mass followed by beta decay to elements of higher atomic number. The ^{255}Fm in the samples, produced from the beta decay of the longer-lived ^{255}Es, was purified and chemically identified by cation-exchange chromatography and detected through the use of alpha particle energy analysis. The name, fermium, was proposed in 1955 in honor of the leader in nuclear science, Enrico Fermi, and the name was subsequently accepted by the IUPAC.

13.2.2 Isotopes of fermium

As can be seen in Table 13.1, there are 19 known isotopes of element 100, ranging from atomic masses 242 through 260. Isotopes with masses 254 through 257 have been identified in samples of plutonium or elements of higher atomic number following neutron irradiation in nuclear reactors. All the other isotopes can only be produced by charged-particle bombardments of targets of elements of lower atomic number at charged-particle accelerators, e.g. cyclotrons, linear accelerators, etc.

The isotope that can be produced in largest quantities on an atomic basis is ^{257}Fm. This isotope is also the nuclide of highest atomic and mass number ever