## Mendelevium (101)

The discovery of mendelevium was one of the most dramatic in the sequence of transuranium element syntheses. It marked the first time in which a new element was produced and identified one atom at a time.

By 1955 we at Berkeley had prepared an equilibrium amount of ~$10^9$ atoms of $^{253}_{99}Es$ by neutron irradiation of plutonium in the Materials Testing Reactor. As the result of a "back of the envelope" calculation done by Ghiorso during an airplane flight, we thought it might be possible to prepare element 101 using the reaction

$$^{253}_{99}Es + {}^{4}_{2}He \rightarrow {}^{256}_{101} + {}^{1}_{0}n$$

The amount of element 101 expected to be produced in an experiment can be calculated using the formula

$$N_{101} = \frac{N_{Es}\,\sigma\,\phi\,(1-e^{-\lambda t})}{\lambda}$$

where $N_{101}$ and $N_{Es}$ are the number of element 101 atoms produced and the number of $^{253}_{99}Es$ target atoms, respectively, $\sigma$ is the reaction cross section (estimated to be ~ $10^{-27}$ $cm^2$), $\phi$ the helium ion flux (~ $10^{14}$ particles/sec), $\lambda$ the decay constant of $^{256}_{101}Md$ (estimated to be ~ $10^{-4}$ $sec^{-1}$) and t the length of each bombardment (~ $10^4$ sec).

$$N_{101} \approx \frac{(10^9)(10^{-27})(10^{14})(1-e^{-(10^{-4})(10^{+4})})}{(10^{-4})} \approx 1 \text{ atom}$$

Thus the production of only one atom of element 101 per experiment could be expected!

Adding immeasurably to the complexity of the experiment was the absolute necessity for the chemical separation of the one atom of element 101 from the $10^9$ atoms of einsteinium in the target and its ultimate, complete chemical identification by separation with the ion-exchange method. This separation and identification would presumably have to take place in a period of hours, or perhaps even one hour or less, because the expected half-life was of this order of magnitude or less. Furthermore the target material had a 20-day half-life and one needed a non-destructive technique of using the target material over and over again.

These requirements indicated the desperate need for new techniques, together with some luck. Fortunately, both were forthcoming. The first new technique involved separation of the element 101 by the recoil method from the einsteinium in the target. The einsteinium was placed on a gold foil in an invisibly thin layer. The helium-ion beam was sent through the back of the foil so that the atoms of element 101, recoiling through