Chemcases.com General Chemistry Case Studies

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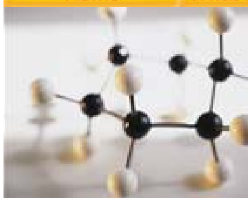

Discovery of the Neutron
Playing with Neutrons (1934-38)
Discovery of Fission (1938)
Discovery of PU-239 (1941)
Controlled Chain Reaction (1942)
Nuclear Fuel Cycle
Uranium Production
Uranium Enrichment
Nuclear Reactors
Reprocessing Spent Fuel
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Case Study

Nuclear Chemistry
Uranium Enrichment

Dr. Frank Settle

Study Index
Introduction

Natural uranium contains 0.7205% U-235, the fissile isotope of uranium. The remaining mass includes 99.274% U-238 and a small amount of U-234 (0.0055%). Uranium-238 does not contribute to slow neutron fission; however, it can react with neutrons to form a fissile isotope of plutonium, Pu-239. Thus U-238 is known as a fertile material, i.e., one that can produce fissile materials. Although U-235 and U-238 are chemically identical, they differ slightly in their physical properties, most importantly mass. This small mass difference allows the isotopes to be separated and makes it possible to increase (enrich) the percentage of U-235 in uranium. Most civilian power reactors use enriched uranium fuel containing 0.8 to 8.0% U-235, known as low enriched uranium (LEU). Weapons grade uranium must contain highly enriched uranium (HEU) with an isotopic concentration greater than 90% U-235.

In producing U-235 for the first atomic bomb, Manhattan Project scientists considered four physical processes for uranium enrichment: gaseous diffusion (effusion), electromagnetic separation, liquid thermal diffusion, and centrifugation. During the project the first three were employed at Oak Ridge to produce enriched uranium for the bomb used at Hiroshima. Centrifugation was abandoned because the technology and materials required to spin corrosive uranium hexafluoride with a rotator at high speeds were not practical for industrial, large-scale separations. However, advances in technology and materials make centrifugation the preferred method of enrichment today.

Gaseous Diffusion

The gaseous diffusion process is based on molecular effusion, a process that occurs whenever a gas is separated from a vacuum by a porous barrier containing microscopic holes (Figure 1). The gas flows from the high-pressure side to the low-pressure side: it passes through the holes because there are more "collisions" with holes on the high-pressure side than on the low-pressure side. Thomas Graham, a Scottish chemist, observed that the rate of effusion of a gas through a porous barrier was inversely proportional to the square root of its mass. Thus lighter molecules pass through the barrier faster than heavier ones.

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Principal Investigator Laurence Peterson
Project Director Matthew Hermes