MATH FOR PHYSICS

Unit 1 Dr. John P. Cise, Professor of Physics, Austin Com. College, Austin, Texas, jpcise@austincc.edu & New York Times , January 14, 2018 by Sarah Varney

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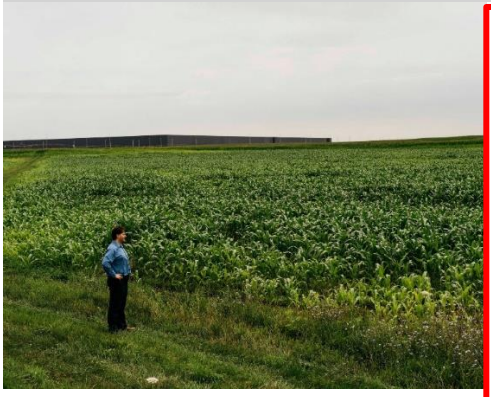
The Race to Supply a Lifesaving Radioisotope



INTRODUCTION: The advantage of imaging agent technetium99m is its short half life of 6 hours. .Technetium99m is a by product of Moly-99. 50,000 patients per day rely on technetium99m for their medical imaging needs. The half life equation is: $N = N_0 e^{-\lambda t}$. At half life $N = 0.5\ N_0$ thus, $0.5 = e^{-\lambda t}$, equation 1. λ = decay constant, t = half life in seconds

QUESTIONS: (a) Find λ for technetium99m which (as listed below as a desirable imaging agent) has a half-life of only 6 hours?, (b) Find λ for Molybdenum-99 where half life is 66 hours? Technetium99m comes from Molybdenum-99.

JANESVILLE, Wis. — In a cornfield here, past the shuttered General Motors plant and the Janesville Terrace trailer home park, a facility not seen in the United States in three decades could soon rise: a manufacturing plant that will make a vital radioactive isotope used to detect cancer and other potentially fatal maladies in millions of people every year.

Nuclear medicine imaging, a staple of American health care since the 1970s, runs almost entirely on Molybdenum-99, a radioisotope produced by nuclear fission of enriched uranium that decays so rapidly it becomes worthless within days. But moly-99, as it's called, is created in just six government-owned nuclear research reactors — none in North America — raising concerns about the reliability of the supply and even prompting federal scientists to warn of the possibility of severe shortages. Some 50,000 Americans each day depend on a strange and precarious supply chain easily disrupted by a variety of menaces: shipments grounded by fog in Dubai, skittish commercial airline pilots who refuse to carry radioactive material and unplanned nuclear reactor shutdowns, including one in South Africa when a mischievous baboon sneaked into a reactor hall. The $100 million Janesville plant, in the hometown of Representative Paul D. Ryan, the speaker of the House, is the first construction project to pass through the labyrinthine nuclear regulatory approval process since 1985 and is being built by Shine Medical Technologies with $25 million in federal funds. Greg Piefer, the company's founder and a nuclear engineer (he drives a Tesla with the license plate "NEUTRON") has big plans for the cornfield: a plant that could manufacture up to 50,000 doses of imaging agent a week. "Ryan called me out of the blue and he said, 'We really want you here,'" Mr. Piefer said.

Linda Nguyen, center, at Stanford University Medical Center to receive an injection of an imaging agent made from Molybdenum-99, a radioisotope known as Moly-99 that is used for diagnostics

Birth of an Isotope

The radioactive isotope injected into the veins of potential heart attack victims or bone cancer patients begins its journey in the heavily guarded American nuclear stockpile. Three companies dominate the American market for moly-99 — Lantheus, Curium and GE Healthcare. They distribute the material to specialized pharmacies around the country where technicians process it into a diagnostic imaging agent called technetium-99. The companies work against a ticking clock: Because of its short half-life, just 66 hours for moly-99 and six hours for the imaging agent, the material must be quickly delivered to hospitals and administered to patients. An injection of moly-99, an imaging agent made from a radioisotope that decays rapidly. Its short half-life meant that patients get less exposure to radioactivity than from other diagnostic tracers.

HINTS: $\ln 0.5 = \ln (e^{-\lambda t})$

$-0.69314 = -\lambda t$

ANSWERS: (a) $\lambda = 3.21 \times 10^{-5}\ s^{-1}$, (b) $\lambda_{Moly\text{-}99} = 2.917 \times 10^{-6}\ s^{=1}$