Chemistry 485

Spring, 2o1o | Problem Set #7
Distributed: Wed., 31 Mar. 2o1o | Due: Mon., 5 Apr. 2o1o
(10 points)

1. The following news report was filed by By Eartha Jane Melzer, 12/12/07 10:36 AM in The Michigan Messenger:

   "Radioactive contamination has been detected in a recently installed monitoring well at the Palisades nuclear power plant, which is located on the shore of Lake Michigan near the city of South Haven and is owned and operated by Entergy. Groundwater samples taken Monday evening showed tritium contamination at a concentration of 22,000 picoCuries per liter, which is above the acceptable level, according to a report filed by the facility with the Nuclear Regulatory Commission. Tritium is a radioactive isotope of hydrogen that combines with oxygen to form tritiated water, also known as super-heavy water. Tritiums half-life the amount of time it takes for something to decay to half of its original value is 12.3 years. The plant is required to report any tritium concentrations over 20,000 picoCuries per liter, the Environmental Protection Agencys maximum allowable level for drinking water."

   (a) The Palisades plant operates at a thermal power of approximately 2500 MW with a thermal efficiency of approximately 30% to produce approximately 750 MWe. Make an estimate of the number of fission reactions per second in the operating reactor if the thermal energy output is 195 MeV/fission of ^{236}U.

   (b) A plausible source of tritium from this nuclear power plant is neutron capture on natural deuterium. Make an estimate of the time a 1 liter sample of natural water would have to be in the reactor core to reach this level of activity. Assume that the neutron flux in the reactor core is $1\text{x}10^{13}$ neutrons/s/cm^2 The thermal neutron capture cross section for deuterium is 0.52 mb.

   (c) It is not likely that the one liter of well-water came directly from the reactor coolant. Subsequent investigation found that a pipe feeding external water storage tanks had developed leaks. The leaked, strongly contaminated water was diluted by percolation through the ground before reaching the well. Make an estimate of this dilution factor with the assumption that the irradiated coolant water was in the reactor core for 10 days before it leaked out, became diluted, and 1 liter of the diluted water was measured.