

Homework 3

Due Friday May 18 in Class

The following two problems concern radioactivity.

1. (10 points) You measure 50,000 decays of a radioactive sample in 20 seconds. You measure the same sample 50 days later and observe only 10,000 decays in 20 seconds. What is the half life of the radioactivity?

2. (15 points) Americium is the only synthetic element to have found its way into the household, where one common type of smoke detector contains about 0.2 microgram of $^{241}\text{Am}^{95}$ as a source of α particles. The α particles ionize the air in the space between two electrodes and this permits a small constant current to flow between the electrodes. Smoke that enters the chamber absorbs the alpha particles, which reduces the ionization and interrupts this current, setting off the alarm. The half-life of $^{241}\text{Am}^{95}$ is 432 years.

(a) How many α particles are emitted per second by 0.2 microgram of $^{241}\text{Am}^{95}$?

(b) What is the mass of a mole of $^{241}\text{Am}^{95}$?

(c) Suppose we start with a mole of $^{241}\text{Am}^{95}$. After 32,400 years, what is the number of atoms that remain?

The next problem concerns the scanning tunneling microscope.

3. (10 points) Suppose that we have a scanning tunneling microscope tip made of a metal with a work function of 4 eV moving at distance x Angstroms above another metal with the same work function. (1 Angstrom = 10^{-10} m.) Calculate the probability that an electron will cross the barrier between the microscope tip and the metal as a function of their separation x .