Radiation Biology, Protection and Applications

(PHYS-450)

EXERCISES

Week 13

Problem 1:

A source of ^{60}Co is used at a hospital. The activity is 5 Ci. Calculate the effective dose that a nurse working in the same room would receive in one working day (8h) if there was no radiation shielding around the source. The average distance to the source can be asumed to be 3 meters. Now, design a radiation protection around the source. The source does not have to be easy to move. Select material and thickness so that the dose to the nurse is limited to 1 μSv per working day.

Problem 2:

In November 2006, the radioisotope ^{210}Po was used to poison and kill the Russian dissident Alexander Litvinenko in London. It took the British authorities a few weeks to realise that the poison was in fact ^{210}Po. Explain two methods that can be used, to identify ^{210}Po (to make sure that it is really ^{210}Po, and not another radioactive material), by using detectors of ionising radiation. Asume that we have a sample (e.g. urine) from the poisoned person, and that the sample contains 1mCi.

It has been estimated that Litvinenko consumed around 10 micrograms of ^{210}Po. Calculate the effective dose during 24 hours. Asume that all of the material stays in the body for the 24 hours, and that it is distributed evenly over the whole body.

Problem 3:

In 1977, a well-preserved dead mammoth was found frozen in ice in Siberia, Russia. A sample of the mammoth was analysed using the carbon-14 dating method. A one-gram sample of pure carbon (from the mammoth) contained 3.945×10^8 ^{14}C atoms. By making the simple assumption that the ^{14}C content in natural carbon was the same when the mammoth died, as it is today (1 ^{14}C atom for 10^{12} ^{12}C atoms), calculate the time (in years before today) when the mammoth died.

Problem 4:

In a hospital, a radioactive source is prepared for a PET investigation of a patient. The source (^{11}C, activity 1.5 Ci) is injected in the patient, and we can assume that it is distributed evenly over the whole body. Calculate the approximate total effective dose delivered to the patient as a consequence of the PET investigation. Also, calculate the effective dose delivered to a nurse sitting 2 m from the patient during the PET procedure (30 minutes). Make a radiation protection design (material, geometry) to decrease the dose to the nurse by a factor of 100.

Problem 5:

Two scientists (Dr. Amy, and Dr. Bernadette) work in a small laboratory where a Mössbauer experiment is prepared. Suddenly, Dr. Amy drops an open ^{57}Co source (200 mCi) on the table in front of her. It takes Dr. Amy 25 seconds before she is able to put the source back in the thick lead container. During the 25 seconds of exposure, Dr. Bernadette stands behind Dr. Amy (i.e. shielded by Dr. Amy's body), unaware of the incident. Calculate the effective dose received by Dr. Amy, and the effective dose recieved by Dr. Bernadette. Make your own (reasonable) estimations of the geometry of the problem.