Chemistry 985

Fall, 2o19 | Problem Set #1

Distributed: Tue., 10 Sept. 19 | Due: Thurs., 19 Sept. 2019

Show your work! State sources of external data!

1. The primary beams at the NSCL are usually stopped in aluminum bars inside the first dipole magnet of the A1900 fragment separator. An example of the radioactivities expected from the reaction of a typical beam with aluminum was discussed in class. These primary reactions create a large number of secondary neutrons and protons (at or near beam velocity) that cause reactions in the iron magnet yoke surrounding the aluminum bars. The most prominent radioactivities after an eight week shutdown of operations have been shown to be ^{56,57,58,60}Co and ^{59}Fe. Answer the following questions related to these activities and state your sources:

   (a) Make a small table with one row for each nuclide and include its half-life in days and the energy and intensity of the **most intense** gamma-ray (or two most intense gamma-rays) from each.

   (b) Assuming that the production *rate* of all of these nuclides is the same, calculate the ratio of the decay rate of ^{58}Co to that of ^{59}Fe after a 14 week running period followed by an 8 week shutdown. For the purposes of this estimate assume that the residual activity in the iron from these nuclides was negligible (yes, this is not such a good assumption for the NSCL).

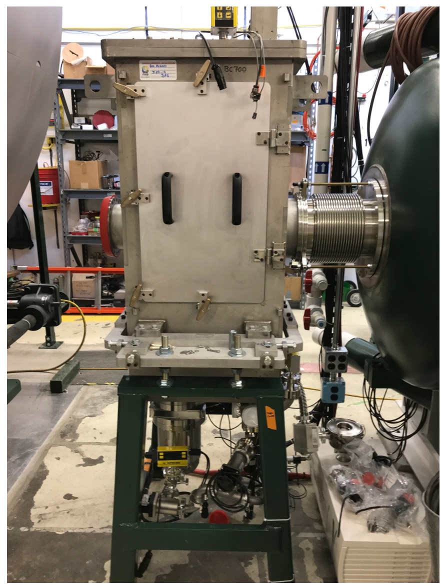
2. Professor Severin presented a seminar on September 5^{th} with some of the results of a recent experiment that his group ran at the NSCL. The experiment used a ^{48}Ca primary beam at 140 MeV/u that was stopped in a special water-filled beam stop in order to collect the ^{47}Ca reaction products as part of an "isotope harvesting" project. The beam stop was essentially a water-filled, pure titanium box. The beam entered the water after passing through a 500 micron thick Ti wall followed by 2 mm of pure water, another 500 micron Ti wall, and finally 3.8 cm of pure water. The downstream wall of the Ti box is 10 mm thick but the beam will not penetrate to this depth. Prof. Severin stated that the beam intensity was 2 particle nanoamps or 40 (electrical) nanoamps, note the beam is fully stripped.

   (a) Use the SRT data from the SRIM energy-loss code package to calculate the kinetic energy lost by the primary ^{48}Ca beam in the entry wall.

   (b) What is the amount of power in Watts delivered into the Ti wall by this beam?

   (c) What is the range of primary ^{48}Ca in the box as described? Show your work.

3. The NSCL is constructing a new beam line to inject fast ion beams into the Cyclotron Stopper magnet. The last element in the beam line is a large vacuum box that holds beam viewers and plates to degrade the beam energy. The vacuum chamber for the charged particle detectors is a large stainless steel box shown in the photograph below. The dimensions of the box are approximately 48 cm long by 96 cm high by 45 cm wide. The vacuum pump (Leybold TurboVac 450i) used to evacuate the box is barely visible below the box and is connected to the chamber by a straight pipe 15 cm, ISO-160 round tube (ID = 160 mm) and a matching gate valve that is 5 cm thick.



(a) Estimate the gas load from the internal surface area of the chamber after 1 hour of pumping using the value of q_{SS} used in class. Ignore the large holes and note that this is highly optimistic because there are large surfaces of beam viewers, etc. inside the box that should be included in this estimation.

(b) Make an estimate of the molecular flow conductance of the hardware between the pump and the detector box.

(c) What is the effective speed of the TMP when it is connected to the degrader box.

(d) Make an estimate of the base pressure of this system assuming that the backing pump does not limit the ultimate pressure.