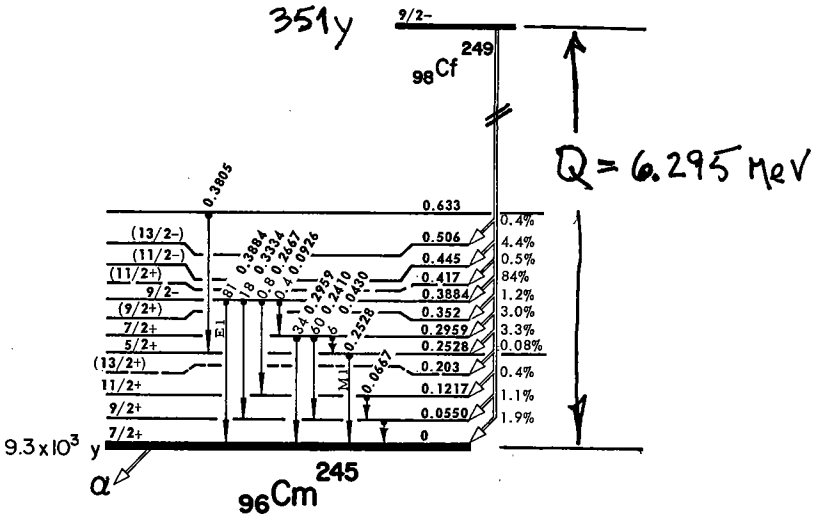
1. (20 points) A ^{249}Cf source attained some notoriety last year because it was missing for a period of time. The source was listed as having a strength of 1.0 μCi on December 7th, 1955 and some information on the decay of ^{249}Cf from the Table of Isotopes, 8th Ed. is shown in the figure below. The source was eventually found without incident.

   (a) (5 pts.) What was the activity of the source in Bq on December 7th, 2005?

   (b) (5 pts.) Indicate the type and energy of the two most prominent primary radiations from this source. (Be specific!)

   (c) (5 pts.) Estimate the range of the most ionizing (highest dE/dx) radiation emitted by this source in solid silicon. Indicate any sources of data.

   (d) (5 pts.) Given the information presented in chapters 1-10, indicate your choice for a reasonable detector to use to search for this source. Justify your answer based on detected radiation, efficiency, and so on.



2. (20 points) A certain experiment was carried out using a certain detector with information carrier drift velocity of 10^7 cm/s and electronics circuit (nonpolarizable) that had a total deadtime of 5 μs per event.

   (a) (10 points) The detector was 300μm thick and had a capacitance of 300 pF. The detector was connected to a network with an effective resistance of 50 Ω. Do you expect the pulse-height from the system to have a maximum at V$\sim$Q/C or to come at some lower value. Justify your answer.

   (b) (10 points) Estimate the true counting rate (in counts/s) for this system when the total number of recorded events was 123,456 events during a 1.0 minute run.

– continue –

3. (20 points) A 250 ℓ/s turbomolecular pump is connected to a scattering chamber by a pipe with a conductance of 300 ℓ/s. The cylindrical chamber (0.5 m high by 1.0 m diameter) is made out of stainless steel with a q=10^{-5} $t^{-1.3}$ W/m^2 where t is given in hours. Estimate the pressure measured inside this chamber after 1 hour of pumping if there are no leaks and the outgassing of the pipe is ignored.

4. (15 points) A recent claim for the discovery of element 114 was based on observing three decay chains during a 1000 hour experiment. The characteristic feature of a good decay chain in this work was that a signal for the implantation of a product nucleus had to be followed within one minute by a nuclear decay event. A variety of products were also implanted into the detector by a number of random processes, albeit at a low rate.

   (a) (5 pts.) A new post-doc in the group wanted to run for two more days. What is probability that another good event would be observed if the run is extended by two days (48 hours)?

   (b) (10 pts.) Referees who are suspicious of this work are often concerned about the occurrence of two random implantation events that are misinterpreted as an implantation and a decay. During this experiment the authors report that 1990 (real + random) implantation events were observed of which only three were claimed to be Z=114. What is the probability that two random implantation events occurred within one minute during this experiment?

5. (20 points) A plastic scintillator (BC-400 material) at the end of the A1900 (so-called extended focal-plane) is used to count the number of particles that pass through it and also provide a time-of-flight signal for various experiments. Each fragment deposits about 0.1 MeV of energy in the scintillator. The plastic scintillator is held in an adiabatic light guide that must collect the light from the plastic foil and transmit it to the photocathode of a photomultiplier tube (assume it was a 2" diameter Hamamatsu 1306 operated at it's recommended voltage of 1000 V).

   (a) (5 points) Estimate the number of photons created by the passage of one particle through the scintillator.

   (b) (5 points) Calculate the quantum efficiency from the cathode radiant sensitivity of this PMT.

   (c) (10 points) What is the minimum transmission of the light guide if the electronic counting circuit has a threshold equivalent to the signal created by ten photoelectrons?