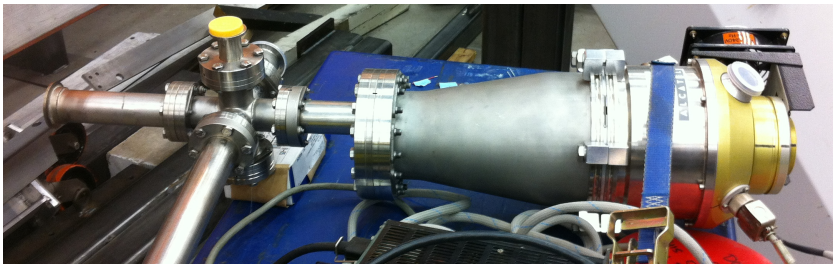
Chemistry 985

Fall, 2o11 — Exam # 2 **Take Home**
Distributed: Fri., 2 Dec. 11, 5:00PM — Due: 6 Dec. 11, 10:00AM

1. (10 points) The photograph below of an amazing piece of vacuum hardware was taken at the NSCL in November, 2011. Estimate the effective pumping speed of this system at the KF-40 flange on the left side of the photograph that has a straight connection to the TMP. The TMP is a 450 L/s pump on a 6-inch ID ISO flange, reduced to a 4-inch ID Conflat flange over a distance of 12 inches, (effectively) connected to a 16-inch long KF-40 tube.

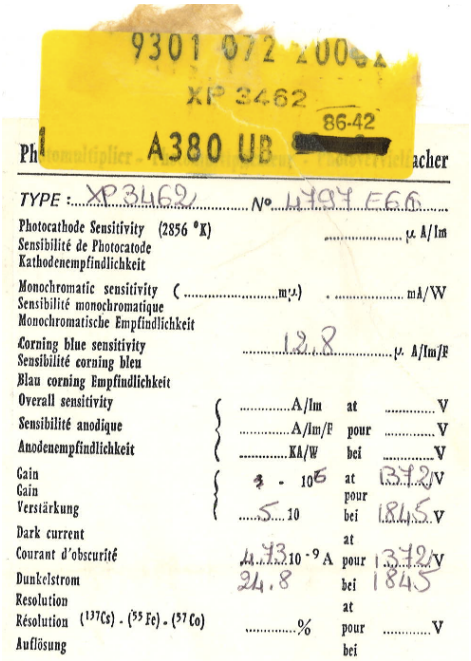


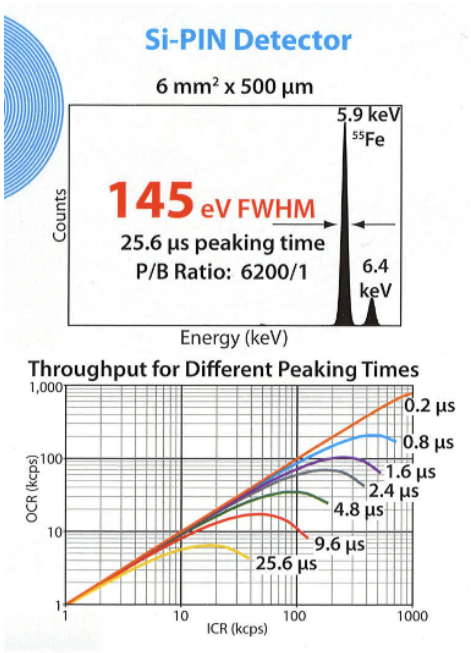
2. The specification sheet shown below was attached to a new XP3462 photomultiplier tube. In case you can't read the numbers the gain is 10^6 at 1372 V, the dark current is 4.73 nA while the gain is $5x10^6$ at 1845 V with a dark current of 34.8 nA.

   (a) (5 points) If the dark current is a white noise, what is the value of the rms noise voltage when the tube is operated at 1372 V with an AC-coupled base that uses a 10 pF capacitor and a 50 Ω impedance?

   (b) (5 points) What is the fractional change in the value of δ for the dynodes when this tube is operated at 1845 V compared to 1372 V?

3. The following figure was cut out of an advertisement sent by the AmpTek company that relates to the properties of a certain x-ray detector when it is connected to their electronic DAQ system.





(a) (2 points) Make an estimate of the system ENC with a 25.6μs shaping time based on the information in the spectrum for the ^{55}Fe source.

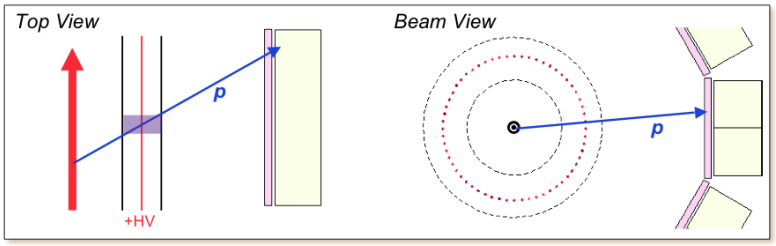
(b) (2 points) Where does the observed radiation come from and what is the fractional attenuation of the lower energy photon in the full thickness of the detector material?

(c) (2 points) What can be said about the deadtime response of the AmpTek electronics simply based on the information in the figure labeled "Throughput for Different Peaking Times"?

(d) (4 points) Make an estimate of the value of the system deadtime for the (red) curve labelled 9.6 μs.

4. The ANASEN detector being developed for experiments at ReA3 uses a combination of a gas proportional chamber with silicon strip detectors backed by CsI to identify charge-particle reaction products with a ΔE-ΔE-E technique. Unusual features of this detector are that the (low intensity radioactive) beam passes through the detector (thick red

arrow in left panel), the gas is the target and the detector has a cylindrical geometry coaxial with the path of the beam.



(a) (4 points) The ANASEN detector uses special resistive anode wires that are only 7μm in diameter (thin red lines in both panels) and a filling gas of 90% He with 10% CO_2 at 250 torr. Estimate the gas gain in this device using the parameters for the similar He/isobutane mixture given in the textbook when the applied voltage is +1500 V.

(b) (2 points) This detector uses two concentric rings of wires that are parallel to the anode and approximately 5 mm away on either side. The inner ring is to shield the sensitive volume from the primary ionization caused by the secondary beam. What is the role of the outer ring?

(c) (2 points) One potential serious problem with this design comes from the propagation of uv radiation from the region with the beam through the grids into the outer region. What is the source of this radiation?

(d) (2 points) The ANASEN detector is intended to study (α,p) reactions in reverse kinematics, among other things. Give a plausible and concise explanation of why CO_2 is added to the filling gas. Clearly this addition introduces background reactions on carbon and oxygen nuclei.

5. (10 points, 2 each) Provide **concise** and accurate answers to the following five questions on various subjects discussed during the course.

(a) Describe the major difference between the operation of a Pirani vacuum gauge compared to that of a thermal couple vacuum

gauge. Indicate why both gauges fail under high vacuum conditions.

(b) The preferred material for gamma-ray detectors used in nuclear reaction studies is n-type germanium. Describe the most likely damage mechanism to the germanium crystals in nuclear reaction studies, the way to repair it, and why vacuum is applied to the detector during the repair process.

(c) The Department of Homeland Security has made a big push to replace their "Portal Monitors" based on plastic scintillators with some other material for spectroscopic identification of radioactivities. Explain the fundamental deficiency of the present portal monitors and indicate the important properties of the active component that would make a better portal monitor.

(d) The Users Manual for the XIA-Pixie-16 digital data acquisition system does not specify the type of ADC used to convert the input signal. Give a plausible architecture (i.e., type) for an ADC that could be used in this module and justify your choice. The only relevant statements I could find in the manual are: "The ADC digitizes each of the 16 incoming signals at 100 MSPS with a precision of 12-bit. The ADC has an input range of 2V."

(e) Give separate reasons for using: (a) the shortest possible connection between a radiation detector and its preamp, and (b) for using a twisted-pair connection between the preamp and the next stage of the signal processing system?