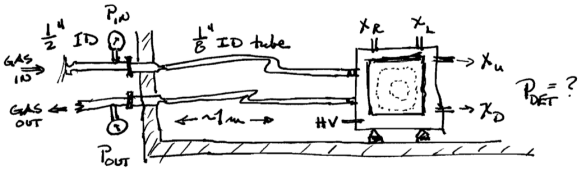
Chemistry 988

Spring, 2oo9 Exam # 1 Practice

Distributed: Tues., 24 Feb. o9 Due: ?

1. The PPAC detectors used at the NSCL are connected to a gas flow system that measures the gas pressure outside the chamber and not in the counter itself. The gas handling system is usually connected to the chamber with large diameter pipes (0.5 in) but with relatively small diameter pipes inside the chamber. Depending on how the hoses are connected the pressure might be measured on the inlet side or on the outlet side.

   The detector is made up of parallel plates, as the name implies, that have an effective area of 10x10 cm^2 and are separated by 3 mm. The signals are created by the passage of high velocity heavy-ions along the path of approximately 3 mm in iso-octane gas, C_8H_{18}. This gas has the essentially the same "W" as methane but a higher density. The device uses charge-division on a resistor chain to provide the position sensitivity.



   (a) Imagine that the PPAC is used in a a cylindrical scattering chamber (1 m diameter, 0.4 m tall). Estimate the amount of time it would take to "rough out" the chamber from 1 bar to 1 mbar with an Alcate-2021 mechanical pump when the PPAC is **not** present and full speed of the roughing pump can be used. The lecture notes show that the model 2021 pump has a constant speed of $S = 16\ m^3/hr$ over this entire pressure range. [Note: This pressure is unreasonably low for roughing and leads to a long time. A much more realistic pressure would have been 200 mbar.]

   (b) Estimate the amount of time it would take to rough-out the same chamber with the same mechanical pump with the PPAC inside the chamber. In order to

protect the fragile, thin widows of the PPAC, the speed of the pump must be decreased with a hand-operated valve. Under these conditions during the pump-down the effective speed of the pump can be written as: $(1 - \frac{P}{1050}) * S$ [Note: similar to previous part, this pressure is so low that the decrease in pumping speed has essentially no effect.]

(c) The flow meter on the gas handling system shows that the typical value of the gas flow is 0.2 SCFH when the inlet pressure, P_{IN}, is 5 mbar. Make an estimate of the gas pressure in the detector, P_{DET}. [Note: this estimate depends critically on the viscosity of the iso-octane gas which is hard to find... I used $\eta = 1\mu$Pa-s]

(d) (1) During the early experiments at the NSCL the experimenters observed that the overall efficiency of a PPAC detector was low for particles like ^{19}C. (2) Recent experimenters detecting particles like ^{38}Ca generally observe a high efficiency except near the edges of the detector. Explain the (different) causes of these two losses of efficiency. Assume that the PPAC's were operated under the same conditions of gas, gas pressure, and electronic readout.

(e) Estimate the size of the two voltage signals, "up" and "down", created by a particle that deposits 1 MeV of energy in a column of ion pairs at the center of the detector. Use the capacitance of the parallel plates and assume the signal goes into a 50Ω circuit. [Note: use the figure from lecture to make a rough estimate of α/E and notice that E is given in V/cm both axes of this figure.]

2. Estimate the size of the signal in coulombs created by a 1332 keV photon that is completely absorbed in a CsF crystal attached to a knock-off 10-stage photomultiplier that has $\eta = 0.15$ and $\delta = 4.5$ The PMT is mounted in a way that collects 25% of the photons emitted by the CsF. [Note: see NIM **179** (1981) 271 for discussion of CsF, they suggest that the light yield is ≈4% that from NaI(Tl).]

3. Make an accurate sketch of the features that would be present in a pulse-height spectrum obtained from a *small* inorganic scintillation crystal in a close-fitting lead shield that is thick enough to absorb external background radiation. The device is used to measure the potassium content of various materials via the decay of naturally occurring ^{40}K. Indicate what features you expect to be present.