Chemistry 988

Spring, 2oo9 | Problem Set #1
Distributed: Thurs., 22 Jan. o9 | Due: Thurs., 29 Jan. o9

1. ^{134}Cs sources are often used to calibrate photon detectors. In contrast to the more widely available ^{137}Cs isotope available as a fission product from uranium, the lighter isotope has to made by a neutron capture reaction. Be sure to cite any references that you use to answer the following questions.

   (a) Give the half-life, the daughter nucleus, and the primary radiations that are emitted by the heavier isotope, ^{137}Cs.

   (b) Give the half-life, the daughter nucleus, and the primary radiations that are emitted by the lighter isotope, ^{134}Cs.

   (c) Aside from the half-lifes and energies, what is the most important difference between the photons emitted by these two isotopes.

   (d) A graduate student has a source prepared to calibrate a particular detector system. Calculate the activity of a 50 mg sample of pure cesium that is exposed to a flux of 1×10^{13} thermal neutrons/cm^2/s in a nuclear reactor for 1.00 minute at the end of the irradiation. The cross section for the (n, γ) reaction under these conditions on the target nucleus is 29 barns. (A *barn* is 100 fm^2.)

   (e) Calculate the activity of this sample 23 years later when the professor is ready to retire and the student has long since graduated.

2. Estimate the final pressure inside a stainless steel beam line at the NSCL that is 10 meters long and has an inner diameter of 10 cm. This line is pumped by a 100 l/s turbomolecular pump with a 10 cm aperture that is connected to the beamline with an 90° elbow with 20 cm long arms at one end of the beam line. Use the estimate from lecture for the off-gasing constant for the walls.

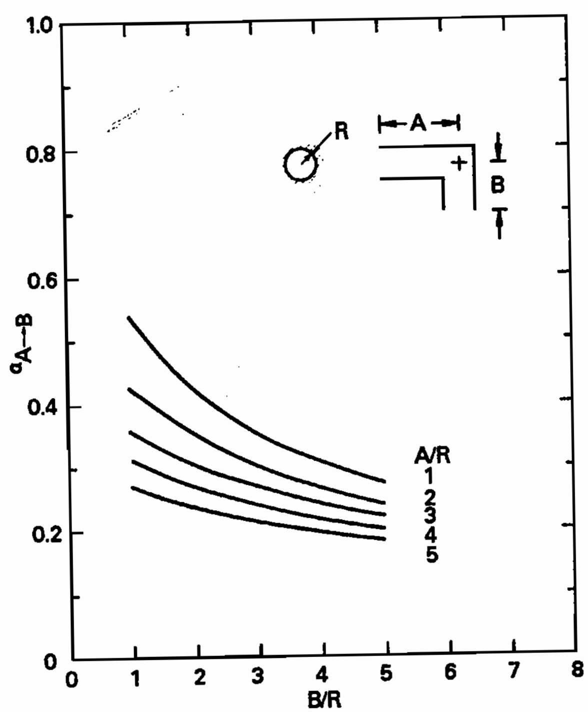

Fig. 3.10 Molecular transmission probability of an elbow. Reprinted with permission from *J. Appl. Phys.*, 31, p. 1169, D. H. Davis. Copyright 1960, The American Institute of Physics.

Table 3.1 Transmission Probability *a* for Round Pipes

l/d	*a*	*l/d*	*a*
0.00	1.00000	1.6	0.40548
0.05	0.95240	1.7	0.39195
0.10	0.90922	1.8	0.37935
0.15	0.86993	1.9	0.36759
0.20	0.83408	2.0	0.35658
0.25	0.80127	2.5	0.31054
0.30	0.77115	3.0	0.27546
0.35	0.74341	3.5	0.24776
0.40	0.71779	4.0	0.22530
0.45	0.69404	4.5	0.20669
0.50	0.67198	5.0	0.19099
0.55	0.65143	6.0	0.16596
0.60	0.63223	7.0	0.14684
0.65	0.61425	8.0	0.13175
0.70	0.59737	9.0	0.11951
0.75	0.58148	10.0	0.10938
0.80	0.56655	15.0	0.07699
0.85	0.55236	20.0	0.05949
0.90	0.53898	25.0	0.04851
0.95	0.52625	30.0	0.04097
1.0	0.51423	35.0	0.03546
1.1	0.49185	40.0	0.03127
1.2	0.47149	50.0	0.02529
1.3	0.45289	500.0	0.26479×10^{-2}
1.4	0.43581	5000.0	0.26643×0^{-3}
1.5	0.42006	∞	$4d/3l$