

Chem 985
Fall / 2017

Exam 1

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1) a A - backscattered photons $E_\gamma \sim \frac{511}{2} \text{ keV}$

B - $E_\gamma \sim 511 \rightarrow$ annihilation radiation

C - $E_\gamma \sim 1461 - 511 \text{ keV} = 950 \text{ keV}$ first escape peak

D - $E \sim 1461 - 256 \text{ keV} = 1205 \text{ keV}$ Compton Edge

b $\text{Act} = \phi_{0.14} \frac{Bq}{kg} \times \phi_{0.63\phi} \frac{kg}{kg} = \phi_{0.0882} Bq$

Uncertainty $= \frac{\phi_{0.14}}{\phi_{0.14}} = \frac{1}{14} = 5 \%$ $\sigma = \frac{1}{\sqrt{N}}$ Poisson

6 $\frac{1}{14} = \frac{1}{\sqrt{N}} \rightarrow N = (14)^2$

$t = \frac{N}{\text{rate}} = \frac{(14)^2}{\phi_{0.0882} / s} = 2222. s \rightarrow 37 \text{ min}$

2) a $\eta = \frac{N_{\text{elect}}}{N_{\text{photons}}} \quad ; \quad \text{Rad Sens.} = \phi_{0.0882} \frac{\lambda}{w} = \frac{N_{\text{elect}} * \eta_e}{N_{\text{phot}} * \frac{hc}{\lambda}}$

b

$$\begin{aligned} \therefore \frac{N_{\text{elect}}}{N_{\text{phot}}} &= \phi_{0.0882} \frac{\lambda}{w} \frac{hc}{\lambda} \frac{1}{\eta_e} \\ &= \phi_{0.0882} \frac{\text{Coul/s}}{\text{J/s}} \frac{6.626 \times 10^{-34} \text{ J-s} \times 3 \times 10^8 \text{ m/s}}{42 \phi \times 10^{-9} \text{ m} \times 1.602 \times 10^{-19} \text{ Coul}} \\ &= \phi_{0.236} \end{aligned}$$

2d4

2) b Gain = $M = (S)^N$ $N=12$, Gain = 3.7×10^7 from data sheet

$\text{3} \times 10^7 = (S)^{12} \rightarrow S = \sqrt[12]{3 \times 10^7} =$

$$\ln(3 \times 10^7) = 12 \ln S$$

$$1.435 = \ln S \rightarrow S = e^{+1.435} = 4.20$$

3) a $PS = -V \frac{dP}{dz} \rightarrow -\frac{S}{V} dt = \frac{dP}{P} \rightarrow -\frac{St}{V} = \ln P \quad \begin{bmatrix} t, P(t) \\ t=0, P_0 \end{bmatrix}$

$$\text{Base } P = 1.3 \times 10^{-2} \text{ mbar} \quad \dot{V} = 250 \text{ l/min}$$

$$P_0 = 10^3 \text{ mbar} \quad V = 37.76 \text{ l}$$

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$$P = P_0 e^{-\frac{S}{V}t} \rightarrow \ln\left(\frac{P}{P_0}\right) = -\frac{S}{V}t \rightarrow t = -\frac{V}{S} \ln\left(\frac{P}{P_0}\right)$$

$$t = -\frac{37.76 \text{ l}}{250 \text{ l/min}} \ln\left(\frac{1.3 \times 10^{-2}}{10^3}\right) = -0.151 \text{ min} \ln(1.3 \times 10^{-5}) \\ = -0.151 \text{ min} [-11.25] \\ = 1.7 \text{ min}$$

b Compression Ratio = $\frac{\text{Foreline Pressure}}{\text{Base Pressure}} \rightarrow \text{Base P} = \frac{\text{Fore P}}{\text{Compression Ratio}}$

2 Base P = $\frac{1.3 \times 10^{-2} \text{ mbar}}{1 \times 10^9} = 1.3 \times 10^{-11} \text{ mbar}$ (8)

c $Q = PS \rightarrow P = \frac{g A}{\beta}$ at equilibrium

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3) c - continue $P = \frac{Q \Delta}{A}$ $Q = 8.5 \times 10^{-6} \frac{\text{Pa} \cdot \text{m}}{\text{s}}$, $\Delta = 55 \phi \text{ f/m}$

5) Area = $2 \times (A_{\text{WALL}} + A_{\text{TDP}} + A_{\text{SIDE}}) = 2(24 \times 24 + 24 \times 4 + 24 \times 4)$
 $= 2 \times (576 + 96 + 96) \text{ sq inch} = 1536 \text{ sq inch}$
 $= 1536 \text{ in}^2 \times \left(2.54 \frac{\text{cm}}{\text{in}} \times 10^2 \frac{\text{m}}{\text{cm}}\right)^2 = 4.991 \text{ m}^2$

$$P = \frac{Q}{A} = \frac{8.5 \times 10^{-6} \frac{\text{Pa} \cdot \text{m}}{\text{s}} \times 4.991 \text{ m}^2}{55 \phi \frac{\text{f}}{\text{s}} \times 10^{-3} \frac{\text{m}^3}{\text{l}}} = \frac{8.4 \times 10^{-6} \frac{\text{Pa} \cdot \text{m}^3}{\text{s}}}{\phi \cdot 55 \phi \frac{\text{m}^3}{\text{s}}}$$

$$P = 1.5 \times 10^{-5} \text{ Pa} \quad \rightsquigarrow \quad P = \frac{760 \text{ torr}}{101,325 \text{ Pa}} \times 1.5 \times 10^{-5} \text{ Pa} = 1.1 \times 10^{-7} \text{ torr}$$

4) rate = $\frac{3\phi \text{ events}}{21 \text{ days}}$ $t = 1d$

6) Prob of an event within time "t" = $1 - e^{-rt}$

$$\text{Prob of NOT an event within time "t"} = 1 - (1 - e^{-rt}) = e^{-rt}$$

$$= e^{-\frac{3\phi}{21} \times 1} = e^{-1.429} = 0.24\phi$$

5) a Fano factor - correction to the statistical estimate of the number of ion-pairs created in detector due to the "exact" or finite number created in pure materials

b true coincident summing requires two particles (photons usually) from the same event (decay) to strike one detector within resolving time; ~~thus~~ thus one particle per event = no coincident summing

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- 4) c Bragg Peak is the maximum energy loss rate for a charged particle as a function of range in a given material
- d NE-213 (Table 8.1 say pulse shape discrimination) neutrons and rays have different dE/dx in material which leads to different pulse shape of light due to different contributions from the singlet-singlet and triplet-singlet transitions
- e the signal in a wire anode proportional counter is created by the motion of the cations away from the wire
- f the intrinsic efficiency is ~~the~~ a measure of a detector to radiation independent of all other factors. Total efficiency is ~~the~~ a measure of a detector response that includes all factors including the intrinsic efficiency
- g high vacuum implies molecular flow - particles move from wall to wall without collisions - coiled tubes are particularly bad with large surface areas

