chapter 4

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[redacted]

(1) $V_{max} = \frac{Q}{C} = \frac{10^{6} \cdot (-1.602 \cdot 10^{-19})\ C}{100 \cdot 10^{-12}\ F}$

$= -1.6 \cdot 10^{-3}\ V$ ✓

(4) $RC = (300 \cdot 10^{-12})\ \text{Farads}\ (10{,}000)\ \text{Ohms}$

$= 3\ \mu s \gg 150\ ns$ ✓

Therefore

$RC \gg t_c$

So we have a large collection circuit time constant

(7) in order to resolve the two peaks their sepperation should be $\approx$ FWHM

So

$490 - 435 = 55 = FWHM$

We use the larger point to get the most conservative estimate, so

$\frac{55}{490} \approx 11\ \%$ needs to be a factor of two better otherwise you get one blob

(11) So $d \approx R\theta$

$\frac{.5}{360} = \frac{\theta}{2\pi}$

Area of the moon $= \frac{\pi d^2}{4} = \frac{\pi R^2 \theta^2}{4}$

$\theta = .0087$ radians

Prob. $= \frac{\text{Area of the Moon}}{\text{S.A. of the Sky}} = \frac{\frac{\pi d^2}{4}}{4 \pi R^2} = \frac{\theta^2}{16} = 4.76 \cdot 10^{-4}\ \%$ ✓

(12) The # of Decays equals 20,000 per second.

The solid angle is given by

$$\Omega = 2\pi \left(1 - \frac{d}{\sqrt{d^2 + a^2}}\right)$$

$$= 2\pi \left(1 - \frac{20}{\sqrt{20^2 + 5^2}}\right)$$

$$= .1876$$

The probollity a particle emitted will hit the detector is given by

$$\frac{\Omega}{4\pi} = .0149 = 1.5\% \checkmark$$

So the # of particles incident on the detector is

$$20{,}000 \times \frac{\Omega}{4\pi} = 298 \frac{\text{counts}}{\text{sec}}$$

The # of 1 MeV particles detected in a sec is

$$298 \times .8 \times .12 = 28.7 \frac{\text{counts}}{\text{sec}}$$

?

in a 100 sec the detector would see ≈

$$28.7 \times 100s \approx 2{,}870 \text{ counts}$$

(13) We know the following relation holds for the Activity at the two times

$t_1 = 12{:}00 \qquad t_2 = 12{:}40$

$$n_2 = n_1 e^{-\lambda(t_2 - t_1)}$$

$$\frac{n_2}{n_1} = e^{-\lambda(t_2 - t_1)} = C_1$$

For a low rate $n \ll 1/\tau$ we can say

$$m \approx n(1 - n\tau)$$

So we have two equations

$$m_1 = n_1(1 - n_1\tau)$$

$$m_2 = n_2(1 - n_2\tau)$$

We can simplify using

$$n_2 = n_1 C_1$$

So

$$m_2 = n_1 C_1 (1 - n_1 C_1 \tau)$$

Solving for τ we get

$$\tau = \frac{1}{n_1 C_1} - \frac{m_2}{(n_1 c_1)^2}$$

plugging this in we get

$$m_1 = n_1\left(1 - \frac{1}{C_1} + \frac{m_2}{n_1 C_1^2}\right)$$

$$= n_1(1 - 1/C_1) + m_2/C_1^2$$

$$n_1 = \frac{1}{1 - 1/C_1}\left(m_1 - \frac{m_2}{C_1^2}\right)$$

$$C_1 = \exp\left[-\frac{\ln(2)}{3240} 2400\right] \approx .5984$$

$m_1 = \frac{131,340}{60} = 2189$ c/s $\quad m_2 = \frac{43,384}{60} = 1556.4$ c/s

So

$n_1 = 3214$ counts/sec at 12:00 ✓ good

(14) We Know the dead time loss in non paralyzable detectors is given by

$$n_{loss} = n - m$$

So we want

$$2(n - m_A) = (n - m_B)$$

using that

$$m = \frac{n}{1 + n\tau}$$

So we have

$$n = 2m_A - m_B$$

$$\cancel{n} = \frac{2\cancel{n}}{1 + n\tau_A} - \frac{\cancel{n}}{1 + n\tau_B}$$

$$(1 + n\tau_B)(1 + n\tau_A) = 2(1 + n\tau_B) - (1 + n\tau_A)$$

$$\tau_B\tau_A n^2 + (\tau_B + \tau_A)n + \cancel{1} = \cancel{1} + n(2\tau_B - \tau_A)$$

$$\tau_B \tau_A n^2 = n\tau_B - 2n\tau_A$$

$$n = \frac{\tau_B - 2\tau_A}{\tau_B \tau_A}$$

$$= \frac{1}{\tau_A} - \frac{2}{\tau_B}$$

$$\simeq 13{,}333 \ \frac{\text{counts}}{\text{sec}}$$ ✓