1) (a) $A = 2.2 \times 10^{-3}\ \text{Ci} * 3.7\times10^{10}\ \frac{\text{Bq}}{\text{Ci}}\ e^{-\lambda t}$

$\lambda = \frac{\ln 2}{2.64\ \text{yr}} = 0.2626\ \text{yr}^{-1} = 8.29\times10^{-9}\ \text{sec}^{-1}$

(5)

$A = 8.14\times10^{7}\ \text{Bq}\ e^{-\frac{\ln 2 * 209}{2.64 * 365.25}}$

D J F M A M
$t = 31-7+31+28+31+30+31+30+4 = 209\ \text{d}$

$A = 8.14\times10^{7}\ \text{Bq}\ e^{-0.150}$

−1 for approximate Δt

$A = 7.0\times10^{7}\ \text{Bq}$

$\text{alphas} = A * 0.97 = 6.79\times10^{7}\ \alpha/\text{s}$

(or 1.83 mCi)

(b) $A = \lambda N$, $\text{mass} = \frac{N}{N_A}\text{Molar Mass} = \frac{1\ \text{Ci}\times3.7\times10^{10}/\text{s}}{\left(\frac{0.2626\ \text{yr}^{-1}}{3.14\times10^{7}\ \text{s/yr}}\right) N_A} * 252.\ \frac{\text{g}}{\text{mol}}$

(5)

$\text{mass} = \frac{4.42\times10^{18}}{6.02\times10^{23}/\text{mol}}\times 252\ \text{g/mol} = 1.85\times10^{-3}\ \text{g}$

(c) $\rho_A = \frac{1.85\times10^{-3}\ \text{g}}{\pi\ (1.9/2)^2\ \text{cm}^2} = 6.53\times10^{-4}\ \frac{\text{g}}{\text{cm}^2} = 0.653\ \frac{\text{mg}}{\text{cm}^2}$

(5)

(d) $R_{neut} = A * 0.03\ \frac{f}{\text{decay}} * 3.8\ \frac{\text{neut}}{f} = 3.7\times10^{10}/\text{s}\times0.03\times3.8\ \text{n/s}$

(5)

$= 4.22\times10^{9}\ \text{n/s}$

or

$R_{neut} = 1\ \text{Ci} * 0.03\ \frac{f}{\text{decay}} * 3.8\ \frac{\text{neut}}{f} = 0.114\ \text{Ci}$

2) (a) thin central wire in cylindrical geometry provides/produces a high electrical field that is proportional to $1/r$ near the wire

5

(b) the mixture should have a higher gain because it will have an auxillary or extra ionization process called Penning Ionization where excited He^* neutrals can ionize the Ar fill gas.

5

(c) the methane is used to quench the discharge after it has spread along the central wire, i.e. to stop the discharge growth and kill after-pulsing

5

(d) the filling gas gets radiation damaged by the amplification process and will become "used up" if it is not replaced (flowed).

5

3) $Q = P S = 2.5 \times 10^{-7}\,\text{mbar} * 250\,\frac{\ell}{s} = 6.25 \times 10^{-5}\,\frac{\text{mbar-}\ell}{s}$

at equilibrium with no leak

$Q' = P' S = 5 \times 10^{-5} \times 250. = 1.25 \times 10^{-2}\,\text{mbar-}\ell/s$

with leak

$Q(\text{leak}) = Q' - Q \simeq Q' = C\,(P_{OUT} - P_{IN}) = C\,(1\,\text{bar} - 5 \times 10^{-8}\,\text{bar})$

thus $C \simeq Q'/1\,\text{bar} = \frac{1.25 \times 10^{-2}\,\text{mbar-}\ell/s}{1000\,\text{mbar}} = 1.25 \times 10^{-5}\,\ell/s$

for molecular flow $C = \frac{A v}{4} \rightsquigarrow \text{Area} = \frac{4C}{v}$

$$\text{Area} \approx \frac{4 \times 1.25 \times 10^{-5}\ \ell/s \times 10^{-3}\ m^3/\ell}{500\ m/s} = 1 \times 10^{-10}\ m^2$$

$\sim 1 \times 10^{-4}\ mm^2$

$\sim 1 \times 10^{2}\ \mu m^2$

(20)

4) $M = \delta^N$ where N is # of dynodes = 8

$M = 2.7 \times 10^5$ from data sheet

(10)

$$\delta = M^{1/N} = (2.7 \times 10^5)^{1/8} = \underline{\underline{4.8}}$$

5) (a) $t_{max} \simeq \frac{\text{max distance}}{\text{hole velocity}} = \frac{0.3\ mm \times 10^{-3}\ m/mm}{\approx 8 \times 10^6\ cm/s \times 10^{-2}\ m/cm}$ see Fig 11.2

(10)

$= 3.7 \times 10^{-9}\ s$

$\sim 4\ ns$

(b) n-type → electrons are in excess $\rho = \frac{1}{q_e N_e \mu_e}$ Eq 11.11

(10)

N_e = number density = $\frac{1}{q_e \mu_e \rho} = (1.602 \times 10^{-19}\ Coul * 1350\ \frac{cm^2}{Vs} * 10000\ \Omega\,cm)^{-1}$

$N_e = 4.62 \times 10^{11}\ cm^{-3}$

(c) $d \cong \left(\frac{2 \epsilon V}{q_e N_e}\right)^{1/2} \rightsquigarrow V = \frac{q_e N_e d^2}{2 \epsilon}$ Eq 11.18

(10)

$$V = \frac{1.602 \times 10^{-19}\ Coul \times 4.62 \times 10^{11}\ /cm^3 \times (0.03\ cm)^2}{2 * 12 * 8.85 \times 10^{-12}\ \frac{F}{m} * \frac{C/V}{F} * 10^{-2}\ \frac{m}{cm}}$$

$V = ~~37~~$ 31.3 Volts

N.B. - can read value from Fig 11.10

BONUS

5) (d) $R = \frac{FWHM}{E} = \frac{2.354\sigma}{E}$ $\frac{\sigma}{E} = \sqrt{\frac{F}{N}}$ $N = \frac{E}{W}$

(10)

$R = 2.354\left(\frac{FW}{E}\right)^{1/2}$ $F = 0.14$, $W = 3.62\,eV$ Table 11.1

$R = 2.354\left(\frac{0.14 \times 3.62\,eV}{6.00 \times 10^{6}}\right)^{1/2} = 6.84 \times 10^{-4}$

(or in energy units 4.1 keV)