

1) $3.8 \text{ fm} \rightarrow \text{probability}$ see p. 78 in text

$$\textcircled{10} \quad P = \int_0^{3.8} \sqrt{\frac{2}{\pi}} e^{-t^2/2} dt = 0.999855$$

Chance that they are the same $1 - P = 0.000145$

$$\textcircled{5} \quad I = \frac{h}{mv} = \frac{h}{p} \rightarrow p = \frac{h}{I}$$

$$KE = \frac{p^2}{2m} = \frac{h^2}{2mI^2} = \frac{(hc)^2}{2mc^2 I^2} \quad [\text{N.B. } hc = 197.3 \text{ MeV-fm}]$$

$$KE = (197.327 \text{ MeV-fm} * 2\pi)^2$$

$$\frac{2(939.565 \text{ MeV})(0.429 \times 10^{15} \text{ fm/m})^2}{10^9 \text{ mm/m}}$$

$$KE = 3.718 \times 10^{-9} \text{ MeV}$$

$$= 3.718 \times 10^{-3} \text{ eV}$$

photon -3

2b) $\textcircled{5}$ all neutron capture cross sections exhibit a $1/v$ velocity dependence at the lowest energies (derived in lecture). The wavelength is $\lambda \propto \frac{1}{v}$ so cross section should scale linearly with λ

2c) (5) $\phi \cdot 1 \times 10^{-2} = \frac{1}{\sqrt{N}} \rightarrow N_{\text{counts}} \geq (10^3)^2 = 10^6$

Activity (cps) $\geq \frac{10^6 \text{ cts}}{10^3 \text{ sec}} \leftarrow_{\text{geo}} , E_{\text{geo}} = 4.2 \phi 21 \times 10^{-3}$
 (given)

$A (\text{cps}) \geq \frac{10^3}{4.2 \phi 21 \times 10^3} = 2.3798 \times 10^5 / \text{s} \text{ or } \text{Bq}$

$A (\text{Ci}) \geq \frac{2.3798 \times 10^5}{3.7 \times 10^1} / \text{s/Ci} = 6.4318 \times 10^{-6} \text{ Ci}$

Ans - 2

2d) (5) neutrons undergo random absorption in material
 and thus follows an exponential attenuation
 law. Absorption can be arbitrarily large
 but never complete

2e) need manuscript here. $\sigma = \frac{\lambda}{\lambda_0} \sigma_0 , \lambda_0 = \phi.1798 \text{ nm}$
 (see 2b, σ scales w/ λ !!)

$$\sigma_0 = 3840 \text{ b}$$

(from text
p. 521)

$$\sigma = \frac{\phi.469 \phi 5}{\phi.1798} * \cancel{3840} \text{ b}$$

$$= 10.018 \text{ b} \quad (\text{higher due to lower n energy})$$

bad extrapolation - 1

2f) (5) $\epsilon = 1 - e^{-N\sigma t} \rightarrow \ln(1-\epsilon) = -N\sigma t$

$$\frac{\ln(1-\phi.9999)}{-N\sigma} = t$$

$$\therefore \sigma = 10.018 \text{ barn}$$

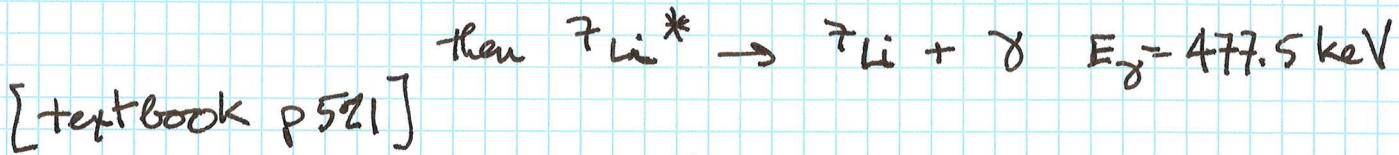
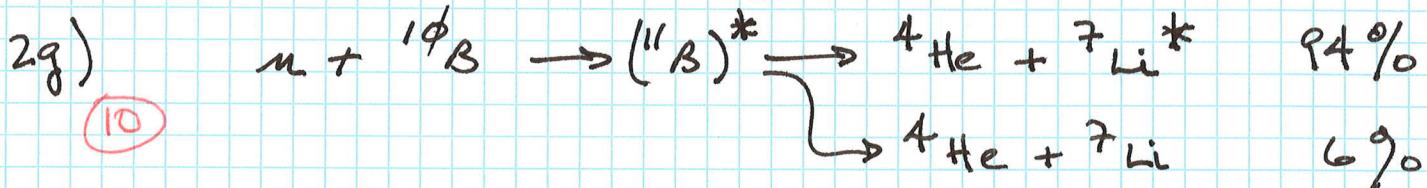
2f-continue)

$$N = \frac{2.52 \text{ g/cm}^3 N_A / \text{mol}}{(4 * 1\phi + 12) \text{ g/mol}} = \frac{2.52 N_A}{52} \text{ /cm}^3$$
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$$t = \frac{\ln(1\phi^{-4})}{-4 \left(\frac{2.52}{52} 6.022 \times 10^{23} / \text{cm}^3 \right) 1\phi. \phi 18 \times 1\phi^3 b \times 1\phi^{-24} \frac{\text{cm}^2}{b}}$$

$$t = \frac{-9.21}{-4 (2.918 \times 1\phi^{22} / \text{cm}^3) 1.00018 \times 1\phi^{-24} \text{ cm}^2} = 7.8 \times 1\phi^{-3} \text{ cm}$$

$$= 78.8 \mu\text{m}$$



- this reaction will emit ${}^4\text{He}$ (alpha part.) and ${}^7\text{Li}$ nuclei every time
- it also emits a 477.5 keV ray 94% of the time

→ Other cases? none that I can think of that emit an alpha and a γ after absorbing a neutron

3a) ① shield should have high atomic number on outside and then decrease towards the middle. Pb(82) Fe(26) Cu(29)

② more common to use elements that are not close in periodic table: e.g. Pb / Sn / Cu

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- 3b) This system only emits one & ray per interaction
 and it is low energy, no pair production etc.

(5)

Thus only "summing" is random summing with
 δ 's from separate nuclear reactions, no
 "coincident summing" in this case.

- 4a) Magnet confines the electrons created inside the
 gauge so that they do not hit the walls and can
 ionize many molecules (and atoms) to create
 the ion current.

(5)

$$\frac{1}{S_{\text{eff}}} = \frac{1}{S_{\text{pump}}} + \frac{1}{C_{\text{pipe}}}$$

(5)

$$\frac{1}{S_{\text{eff}}} = \frac{1}{25\phi} + \frac{1}{5.33} = \phi \cdot 1917$$

$$S_{\text{eff}} = 1/\phi \cdot 1917 = 5.2 \text{ l/s}$$

(big penalty!)

- 4c) Water!!

φ

- 5a) depletion of the oxygen in the layer that creates the
 rectifying junction called the "surface barrier"

(5)

need C_{pipe} in molecular flow
 for $L = 1 \text{ m}$, $d = 35 \text{ mm}$
 see notes...

$$C_{\text{pipe}} = \frac{\pi}{12} \rightarrow \frac{d^3}{L}, V = 475 \frac{\text{m}}{\text{s}}$$

for N_2

$$C_{\text{pipe}} = \frac{\pi}{12} \frac{475 \text{ m}}{\text{s}} \left(\frac{\phi \cdot 0.35^3 \text{ m}^3}{1.0 \text{ m}} \right)$$

$$C = 5.33 \times 10^{-3} \text{ m}^3/\text{s} = 5.33 \frac{\text{l}}{\text{s}}$$

5b)

$\text{POOR QUESTION - NOT GRADED}$

$$t = \frac{\text{area}}{4\pi(7.5)^2} \rightarrow \text{area} = 4\pi(7.5)^2 \times 4.2\phi 21 \times 10^{-3}$$

$$= 2.97 \text{ cm}^2$$

$$= 297 \text{ mm}^2$$

$5\phi 5$

6a) $\textcircled{5}$ the shaping amplifiers since $5\phi \text{ MHz} \rightarrow$ requires only $2\phi \text{ ns}$ to enter one count in scalers.

6b) $\textcircled{5}$ no coincidence required in this system, it just records counts in scalers (no master gate)

6c) $\textcircled{5}$ CAMAC/GPIB: 1 ~~1~~ byte (8 bits)/s

CAMAC data word is 24 bits = 3 bytes

$$\Delta t_{\text{time}} = 14 \text{ scalers} \times \frac{3 \text{ bytes}}{\text{scaler}} / 10^6 \text{ bytes/s} = 42 \mu\text{s}$$

Note more careful analysis shows that the interface to computer using 89phiA has a rate limit of 450 kbytes/s

thus $\Delta t = 14 \times 3 / 450 \times 10^3 = 93 \mu\text{s}$

[but only a few people noticed this ...]

6d) $\textcircled{5}$ Flash ADC tends to have large differential non linearity due to many, many comparators.
Wilkinson ADC has only one comparator DNL should be small

6e) $\textcircled{5}$ Canberra 2phi5 is listed as PREAMP & AMPLIFIER in diagram — it is a preamp —