1a) A $\;{}^{40}_{19}K \rightarrow {}^{40}_{18}Ar + \nu + Q_{EC}$

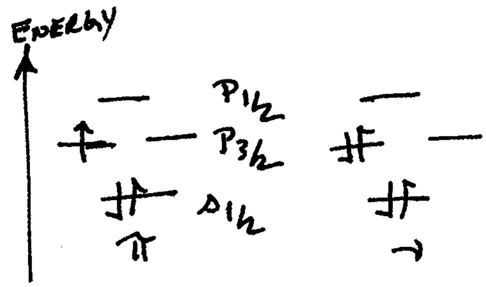
$\searrow {}^{40}_{18}Ar^{\ominus} + \beta^+ + \nu + Q_{\beta^+}$

B $\quad Q_{\beta^+} = \Delta({}^{40}K) - [\Delta({}^{40}Ar) + 2m_ec^2]$

$= -33.535 - [-35.039 + 2 \times 0.511] = {}^{+}0.482 \text{ MeV}$

[β^+ allowed by $\oplus$ Q_β]

1b) A $\;{}^{7}_{3}Li_4$



→ odd particle π $P_{3/2}$

$I = 3/2^-$

B $\;{}^{7}Li^{*}$ would be produced by promoting odd proton up to $P_{1/2}$ state, leave everything else the same

$I = 1/2^-$

1c) A There are no bound nuclei with A = 5 which blocks the formation of heavier nuclei. Only a few heavier nuclei can be made by reactions between He nuclei during the short explosion time.

B Sun runs on the reaction $4p^+ \rightarrow {}^4He^{2+} + 2\beta^+ + 2\nu$

C Sun produces no iron, fraction = 0

D s-process (slow neutron capture) terminates at ${}^{209}Bi$ because heavier nuclei decay back by α decay ($^{210}Po \rightarrow \alpha + {}^{206}Pb$)

1d) Recall $\frac{dE}{dx} \propto K \frac{Aq^2}{E}$

$\frac{dE}{dx}(\text{proton}) = \frac{23\,\text{MeV}}{\text{cm}} = K \frac{1\,(1)^2}{10}$

$K = 230 \frac{\text{MeV}^2}{\text{cm}}$

$$\frac{dE}{dx}\left({}^{40}Ca^{20+}\right) = 230 \frac{\text{MeV}^2}{\text{cm}} \left(\frac{40 \times 20^2}{240\,\text{MeV}}\right) = 15{,}333.\ \text{MeV/cm}$$

Note that it is important that the same material is used for both ions, otherwise we could not evaluate K

1e) NaI has a much higher average atomic number than plastic (CH_2) and so will have a much higher attenuation coefficient for γ rays and have a higher probability of observing γ rays from a source. DHS detectors cannot detect α or β particles due to their short range.

2)
$$\frac{N(235)}{N(238)} = \frac{N_0(235)}{N_0(238)} \frac{e^{-\lambda_{235} t}}{e^{-\lambda_{238} t}} = \frac{2.7 \times 10^{-3}}{1}$$

$\frac{N_0(235)}{N_0(238)}$: assume 1

$$e^{(\lambda_{238} - \lambda_{235})t} = 2.7 \times 10^{-3}$$

$$t = \frac{\ln(2.7 \times 10^{-3})}{(\lambda_{238} - \lambda_{235})} = \frac{-5.915}{-8.292 \times 10^{-10}/\text{yr}}$$

$$\lambda_{235} = \frac{\ln 2}{704 \times 10^6\,\text{yr}} = 9.85 \times 10^{-10}$$

$$t = 7.13 \times 10^9\,\text{yr}$$

$$\lambda_{238} = \frac{\ln 2}{4.46 \times 10^9\,\text{yr}} = 1.55 \times 10^{-10}$$

3) $A = N\sigma\phi(1-e^{-\lambda t})$

$\lambda_F = \frac{\ln 2}{109.7\ min} = 6.32\times10^{-3}/min$

$t = 5.0\ hr \times 60 \frac{min}{hr} = 300\ min$

$(1-e^{-\lambda t}) = 1 - e^{-1.896} = 0.8498$

$$A = \left(\frac{0.1\ cm \times 1.0\ g/cm^3 \times N_A}{20.\ g/mol}\right) 0.30\times10^{-24}\ cm^2 \left(0.5\times10^{-6} A \ast \frac{coul/s}{A} \times \frac{1\ Part}{1.602\times10^{-19}\ coul}\right) \times 0.8498$$

$$A = \left(3.01\times10^{21} \frac{H_2O}{cm^2} \times \frac{1\ O}{1\ H_2O}\right) 3\times10^{-25}\ cm^2 \left(3.121\times10^{12}/s\right) 0.8498$$

$A = 2.396\times10^{9}/s \rightsquigarrow Bq \rightsquigarrow 0.0648\ Ci$

4) a From the web I found that ^{201}Tl is used in these type of diagnoses

b $^{201}_{81}Tl \rightarrow ^{201}_{80}Hg^* + \nu + Q_{ec}$ $T_{1/2} = 3.04$ days

$\hookrightarrow$ emits a γ ray $E = 167$ keV

c Reduction $= 2^{-10} = \frac{1}{1024}$

$N/N_0 = e^{-\lambda t} = e^{-\frac{\ln 2}{T_{1/2}} \times 10 \times T_{1/2}} = e^{-10 \ln 2}$

d $t = 10 \times T_{1/2} = 10 \times 3.04$ days $= 30.4$ days