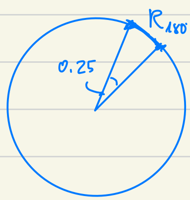
Q.3

a) NaI (Tl) scintillators has a ±10% energy resolution.
Since ^{99m}Tc produces photon at 140keV.
Typical energy window for ^{99m}Tc with NaI(Tl) scintillator and PMT array is 126 - 154 keV.

b) Events with lower energy depositron can stem from Compton Scattering. The scattered photon got deflected from its original direction and has a lower energy. compared to primary photons comming straight into the detector.

c) This corresponds to an event where two or more photon arrive at the detector at the same time, and the culmulated energy is computed as 1 event.



Q5 PET resolution depends on:

1.) Positron range: ^{18}F : $R_{range} = 0.1$ mm

2) annihilation photons' angle deviates from 180°, $R_{180} = \frac{0.25}{360} \times 2\pi \times \left(\frac{90 \times 10}{2}\right) = 1.9625$ mm

3) detector characteristic : $R_{detector} = 2.5$ mm

Thus $R_{sys}^2 = R_{range}^2 + R_{180}^2 + R_{detector}^2$

$= (0.1)^2 + (1.9625)^2 + (2.5)^2$

$= 10.11$

$R_{sys} = \sqrt{10.11} = 3.18$ mm

Q1

$$m = \frac{A(8hrs)}{SA(8hrs)} = \frac{A(8hrs)}{SA(0).e^{\left(\frac{-8\times 60}{\tau}\right)}}$$

We have $T_{1/2}$ for $^{18}F = 110$ min.

$$\tau = \frac{T_{1/2}}{\log(2)} = \frac{110}{\log(2)} = 158.69 \text{ min}$$

$A(8hrs) = 440$ MBq

$SA(0) = 90,000 \times 37 = 3.33 \times 10^6$ MBq

$$\text{Thus, } m = \frac{440}{3{,}33 \times 10^6 \times e^{\left(\frac{-8\times 60}{158.69}\right)}} = 2.72 \times 10^{-3} \mu g$$

Q4

60% in liver $\quad S_{liver-liver} = 3.23 \times 10^{-6}$

30% in spleen $\quad S_{spleen-liver} = 7.2 \times 10^{-8}$

10% in red bone marrow $\quad S_{marrow-liver} = 8.93 \times 10^{-8}$

Biological excretion is ignored so cumulated activity is $\tilde{A} = 1.44 T_{1/2} A_0$

$$= 1.44 \times (6 \times 60 \times 60) \times 100$$
$$= 3{,}110{,}400 \text{ MBq.sec}$$

Thus dose is:

$$D = D_{spleen \to liver} + D_{marrow \to liver} + D_{liver \to liver}$$
$$= \tilde{A}(30\% \times S_{spleen \to liver} + 10\%.S_{marrow \to liver} + 60\%.S_{liver \to liver})$$
$$= 3{,}110{,}400 \times (0.3 \times 7.2 \times 10^{-8} + 0.1 \times 8.93 \times 10^{-8} + 0.6 \times 3.23 \times 10^{-6}) = 6.123 \text{ mGy}$$

For the liver:

$$E = W_{liver}.D = 0.04 \times 6.123 = 0.245 \text{ mGy}$$

Q2

511 keV

	$\rho\,(g/cm^3)$	$\mu/\rho\,(cm^2/g)$	$\mu\,(cm^{-1})$
Bone	1.920	9.022×10^{-2}	0.1732
Tissue	1.060	9.598×10^{-2}	0.102

$$N(+D,-D) = N(a) \cdot e^{-\mu_{tissue}(12+6)} \cdot e^{-\mu_{bone}(2)}$$

$$A(t=0) = 0.25\,MBq$$

$$A(t) = A(t=0) \cdot e^{-\alpha t}$$

where $\alpha = \frac{1}{\tau} = \frac{\log(2)}{T_{1/2}} = \frac{\log(2)}{110\,(min) \cdot 60\,\frac{sec}{min}} = 1.05 \times 10^{-4}\ sec^{-1}$

Let TA be total activity or number of decays over 2min or 120 sec

$$TA = \int_0^{t=120sec} A(t=0) \cdot e^{-\alpha t} \cdot dt$$

$$= \frac{A(t=0)}{-\alpha} \cdot e^{-\alpha t} \Big|_0^{t=120}$$

$$= \frac{A(t=0)}{-\alpha} \left(e^{-\alpha \cdot 120} - 1 \right)$$

$$= \frac{A(t=0)}{\alpha} \left(1 - e^{-\alpha \cdot 120} \right) = 29811791.31 \text{ decays}$$

with $A(t=0) = 0.25\,MBq = 0.25 \times 10^6\,Bq$

$\alpha = 1.05 \times 10^{-4}$

Thus $N(+D, D) = (TA) \cdot e^{-0.102 \times 18} \times e^{-0.1732 \times 2}$

$\simeq 3361892$ coincidence detections