PHYS 415 QUlZ II
Place answers in indicated areas with correct units.

#1- You are calibrating your NaI(Tl) detector with two sources. With the first source a 662 KeV peak appears in channel number \( CH = 200 \). In the second source a 1120 KeV peak appears in channel number \( CH = 400 \).

(a) Find the linear calibration constants \( A \) and \( B \) in the form \( E(KeV) = A + B \cdot CH \).

\[
A = \quad \quad \quad B = \quad \quad \quad
\]

(b) An unknown peak arises in channel number \( CH = 500 \). What is the energy of this unknown gamma radiation?

\[
E_{500} = \quad \quad \quad
\]

\[
\begin{align*}
(a) \quad B &= (1120 - 662)/(400-200) = 2.29 \text{ KeV/ch} \\
\quad A &= 662 - 2.29(200) = 204 \\
(b) \quad E &= 204 + 2.29 \cdot CH = 1349 \text{ KeV @ CH=500}
\end{align*}
\]

#2- A 662 KeV peak in a NaI(Tl) counter has a width (FWHM) of 80 KeV. What is the %Resolution of the detector at this energy?

\[
\%R = \quad \quad \quad
\]

\[
\%R = \frac{\Delta E}{E} = \frac{80}{662} \times 100 = 12.1\%
\]
#3- A gamma ray spectrum of Na$^{22}$ shows the full energy at $E = 511$ KeV. What are the energies of the (a) Compton Edge, (b) Backscatter, and (c) Pb X-ray for this source. Sketch a figure of how the spectrum might appear with (a), (b), (c), and the 511 KeV peak labelled labeled.

$E_{\text{PbXray}} = \phantom{0}0\phantom{0}$

$E_{\text{ComptonEdge}} = \phantom{0}0\phantom{0}$

$E_{\text{Backscatter}} = \phantom{0}0\phantom{0}$

$E_{\text{PbXray}} \sim 75$ KeV

$E_{\text{ComptonEdge}} = 0.511 - E_{\text{Backscatter}} = 0.341$ MeV

$E_{\text{Backscatter}} = \frac{E\gamma}{1 + 3.91 E\gamma} = 0.170$ MeV
#4- We have a standard Cs$^{137}$ source of $A_S = 1 \mu$Ci activity. We receive an unknown source from a vendor. The standard source gives an integrated count of 17411 dpm in our NaI(Tl) detector. The unknown source gives a count of 25039 dpm. What is your estimate of the activity $A_x$ of the unknown source? What is the error on $A_x$? (1Ci = $3.7 \times 10^{10}$ dps)

$$A_x = \ldots \ldots \quad \Delta A_x = \ldots \ldots$$

Find the error in $A_x = (R_x/R_s) A_S$

$$\Delta A_x/A_x = \sqrt{\left(\frac{\sqrt{25039}}{25039}\right)^2 + \left(\frac{\sqrt{17411}}{17411}\right)^2} = 0.0099$$

$$\Delta A_x = 0.0099 \quad A_x = 0.014 \, 1\mu Ci$$

#5- To cross check the activity of the standard Cs$^{137}$ source (#4) we place it at a distance of $R = 20$ cm from the NaI(Tl) detector. The detector face has a diameter of $d=3$ inches. Only 92% of the Cs$^{137}$ decays produce gamma rays. When the gamma ray enters the crystal only 40% of the time is the energy fully collected into the full-energy-peak.

(a) Find the activity $A_S$ of the standard source if we record the integrated count of 7411 dpm (decays per minute). (b) Does it agree with $A_S$ (#4)? Explain.

$$A_S = \ldots \ldots$$

(a) $A_x = A_S \, G \, \epsilon_1 \, \epsilon_2$

$$G = \frac{\pi r^2}{4\pi R^2} = \frac{(3.81\,\text{cm})^2}{4(20\,\text{cm})^2} = 0.0091$$

$\epsilon_1 = 0.92$ fraction of Cs$^{137}$ decays to gammas

$\epsilon_2 = 0.40$ fraction of energy in `full energy peak

$$A_S = \frac{A_x}{G \, \epsilon_1 \, \epsilon_2} = \frac{7411 \, \text{dpm}}{(0.0091)(0.92)(0.40)} = 2.2 \times 10^6 \, \text{dpm}$$

$$A_S = 3.674 \, \text{dps} = 1 \, \mu\text{Ci}$$

(a) In good agreement with #4 for $A_S$