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DOE Radiological Triage Program Analyst Open Book Exam 2022

Name:_____ Date:_____

The following questions test your knowledge relevant to the DOE Radiological Triage program. There is no time limit, you may use any reference materials or software you like, and you may discuss with other analysts. No electronic spectra are provided or needed.

Please send your answers in any convenient form to Mercer@LANL.gov. You may also take the exam using Survey Monkey (which will provide immediate feedback). A score of 80% is required to pass. There are 25 multiple-choice questions each worth 1 point.

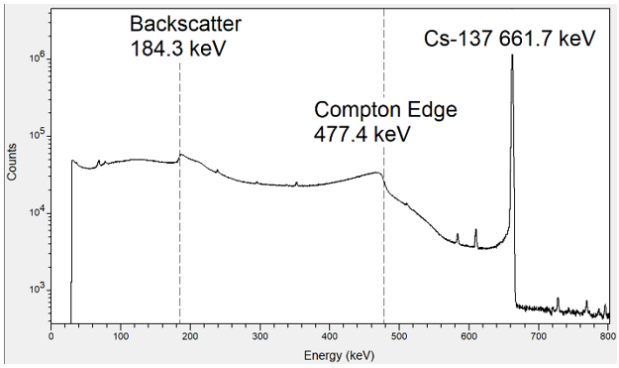
Question 1: For what energy E will the 180° backscatter and Compton edge energies be equal?

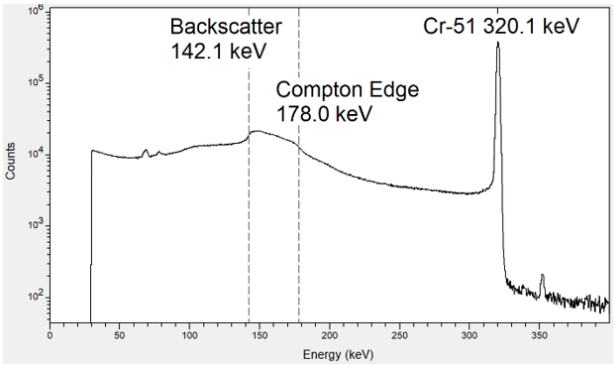
(A) E=511 keV
(B) E=511 keV / 2
(C) E=511 keV / 3

For a gamma ray of energy E, the 180° backscatter gamma ray E_{BS} and the Compton edge E_C will occur at energies:

$$E_{BS} = \frac{E}{1 + \frac{2E}{511\ \text{keV}}} \quad \text{and} \quad E_C = \frac{E}{1 + \frac{511\ \text{keV}}{2E}}$$

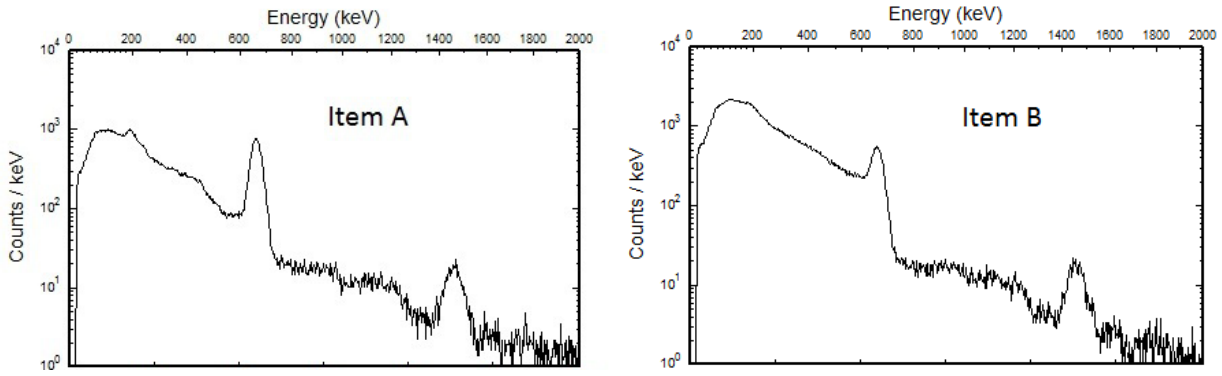
For example, Cs-137 has $E = 661.7\ \text{keV}, E_{BS} = 184.3\ \text{keV}, \text{and}\ E_C = 477.4\ \text{keV}$, and as another example, Cr-51 has $E = 320.1\ \text{keV}, E_{BS} = 142.1\ \text{keV}, \text{and}\ E_C = 178.0\ \text{keV}$.





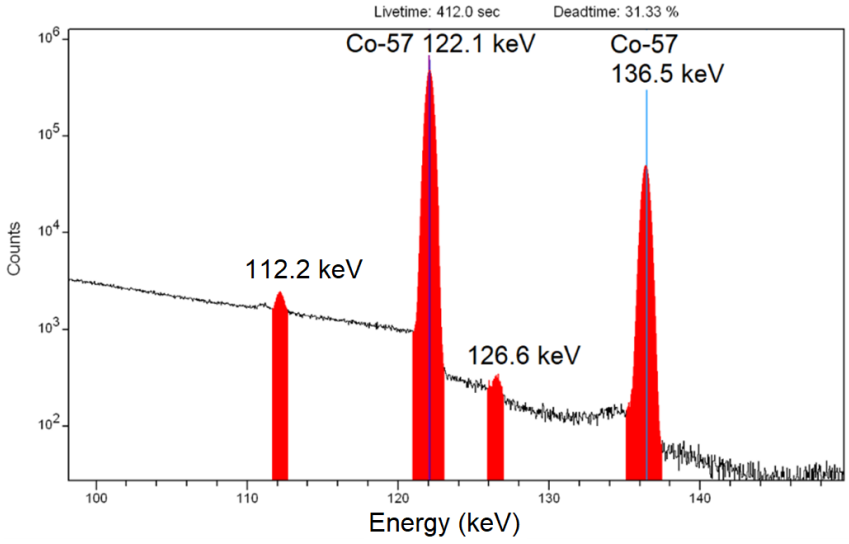
Question 2: The two spectra shown are from two Cs-137 sources with different activities and different amounts of iron (Fe) shielding. Which has the greater amount of shielding?

(A) Item A
(B) Item B



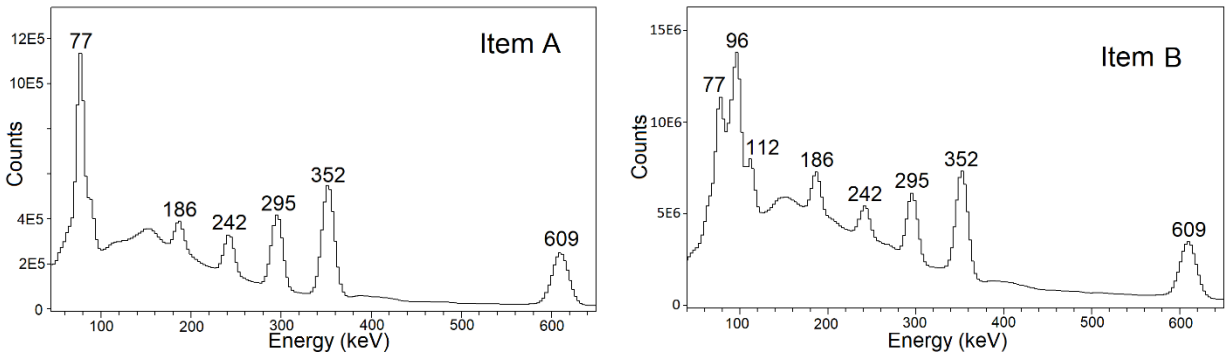
Question 3: The spectrum below shows two large peaks from Co57 at 122.1 and 136.5 keV. In addition, there are two small peaks, each 9.9 keV lower in energy than a strong peak. The detector is a thin planar HPGe. What phenomenon produces two small peaks?

(A) Lower-intensity gamma rays from Co-57
(B) Germanium X-ray escape
(C) Backscatter
(D) Compton scatter



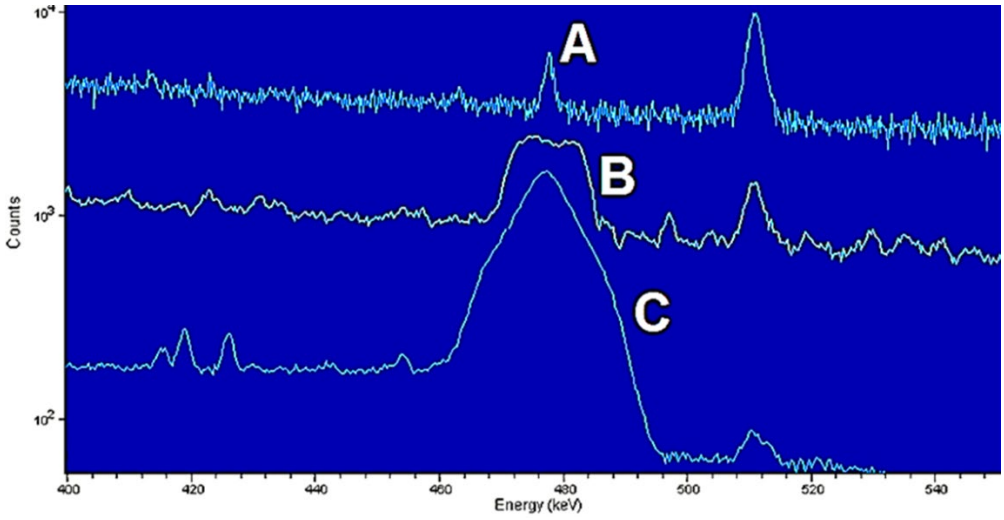
Question 4: The spectra below are from a Ra-226 source and from a sample of unprocessed uranium ore. The detector is based on a $LaBr_3$ scintillator. Which item is uranium ore?

(A) Item A
(B) Item B



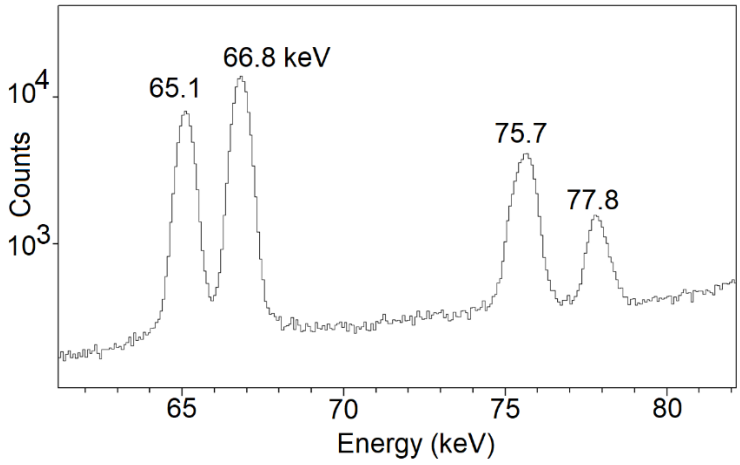
Question 5: The following plot includes peaks from the $^{7}Li(\alpha,\alpha')^{7}Li^{*}$ reaction, the $^{10}B(n,\alpha)^{7}Li^{*}$ reaction, and natural ^{7}Be, all collected with an HPGe detector. All peaks have the same centroid energy (477.6 keV) but have different shapes. Which peak is from natural ^{7}Be?

(A) Peak A
(B) Peak B
(C) Peak C



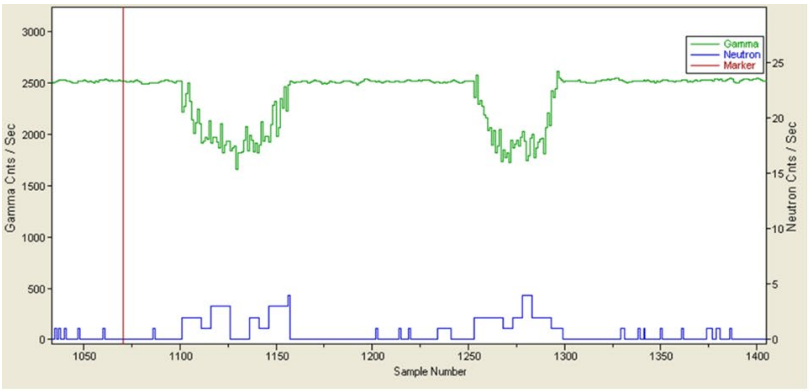
Question 6: The spectrum below shows fluorescent X-rays from which element?

(A) Tungsten (W)
(B) Platinum (Pt)
(C) Lead (Pb)



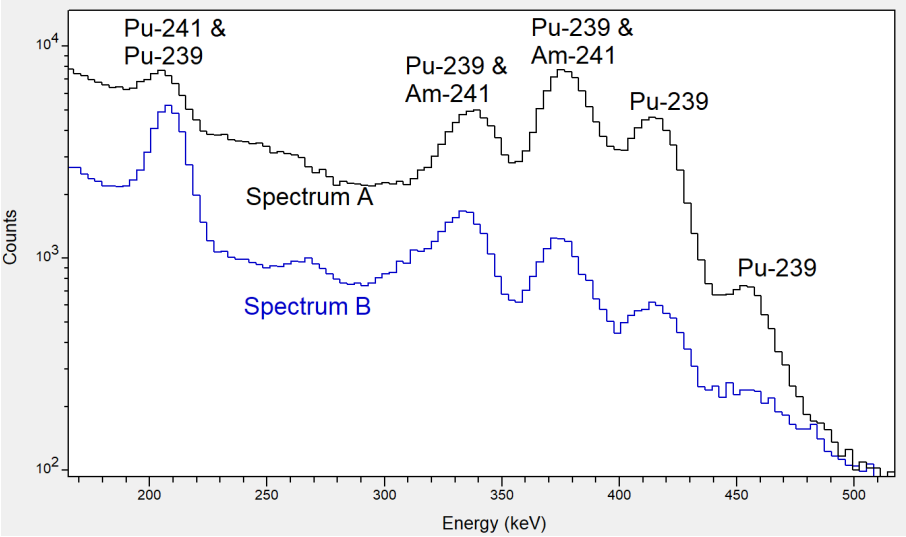
Question 7: The time histogram below shows gamma (green) and neutron (blue) count rates from a vehicle portal monitor in Sri Lanka. Each gamma sample is 0.2 seconds in duration. Two occupancies are shown (an occupancy is when a vehicle is between the monitor panels). What causes the reduction of the gamma count rate during the occupancies?

(A) High neutron rates cause a high deadtime.
(B) Vehicles moving in the adjacent lane artificially increase the background.
(C) Radio transmissions interfere with plastic scintillator detectors.
(D) Dense cargo blocks (occludes) some of the natural background radiation.



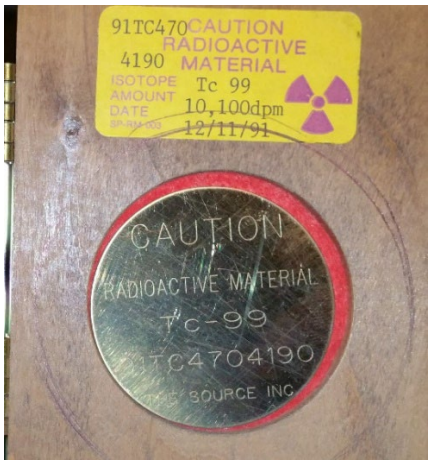
Question 8: The two spectra shown below are from weapons-grade Pu (WGPu) and from reactor-grade Pu (RGPu), both approximately 40 years old. In both cases the detector crystal is $LaBr_3$. Which spectrum is from WGPu?

(A) Spectrum A (Black)
(B) Spectrum B (Blue)



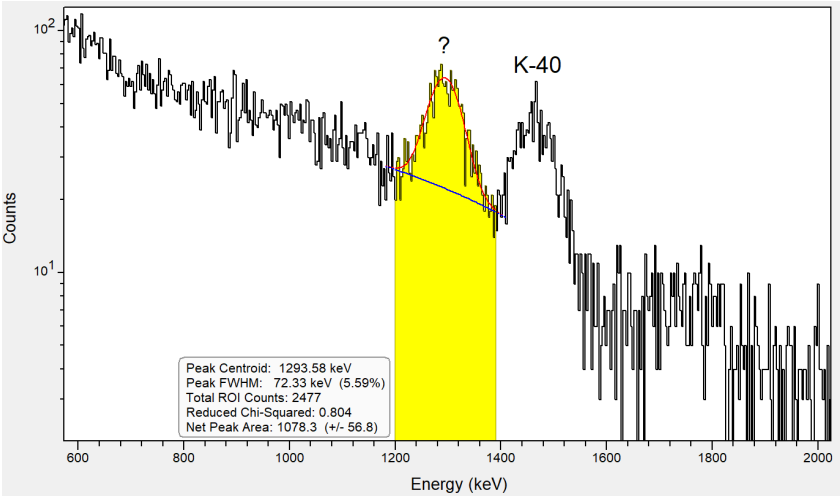
Question 9: What is the half-life of the Tc-99 ground state?

(A) 6.02 hours
(B) 2.76 days
(C) 211,000 years



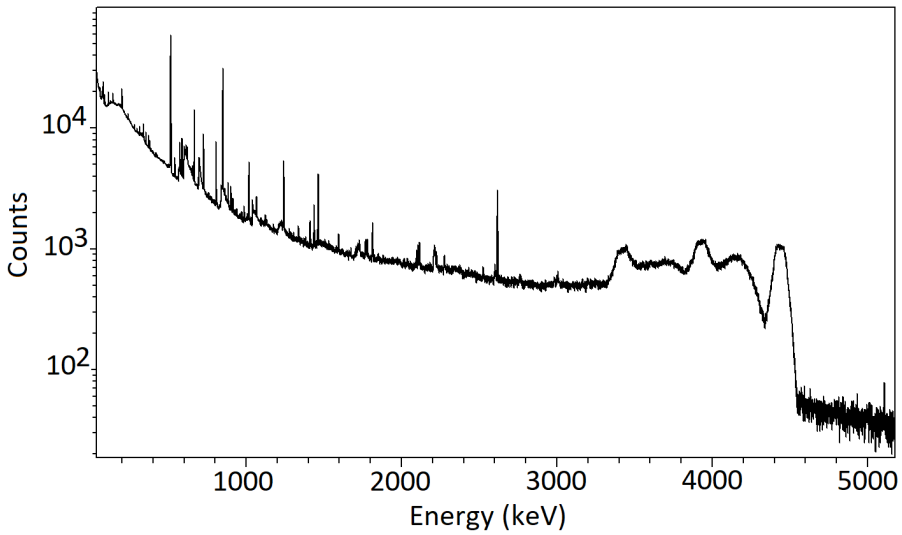
Question 10: What common nuclear reactor effluent generates a peak at 1293.6 keV?

(A) H-3 (Tritium)
(B) Ar-41
(C) Kr-85
(D) Xe-133



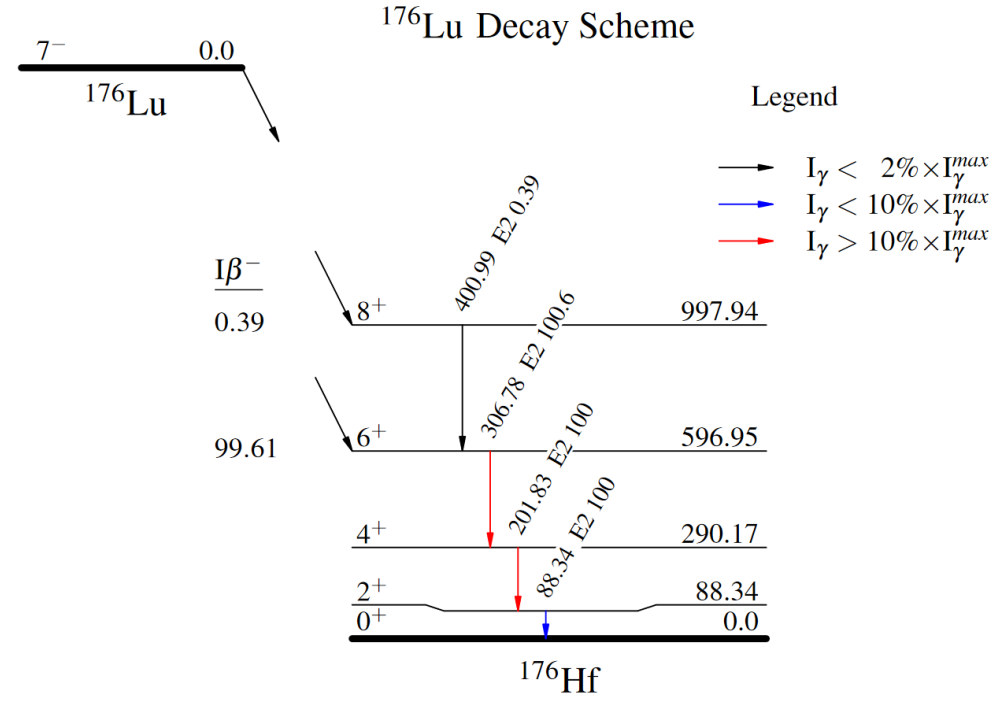
Question 11: A spectrum collected from a neutron source appears below. The source is likely:

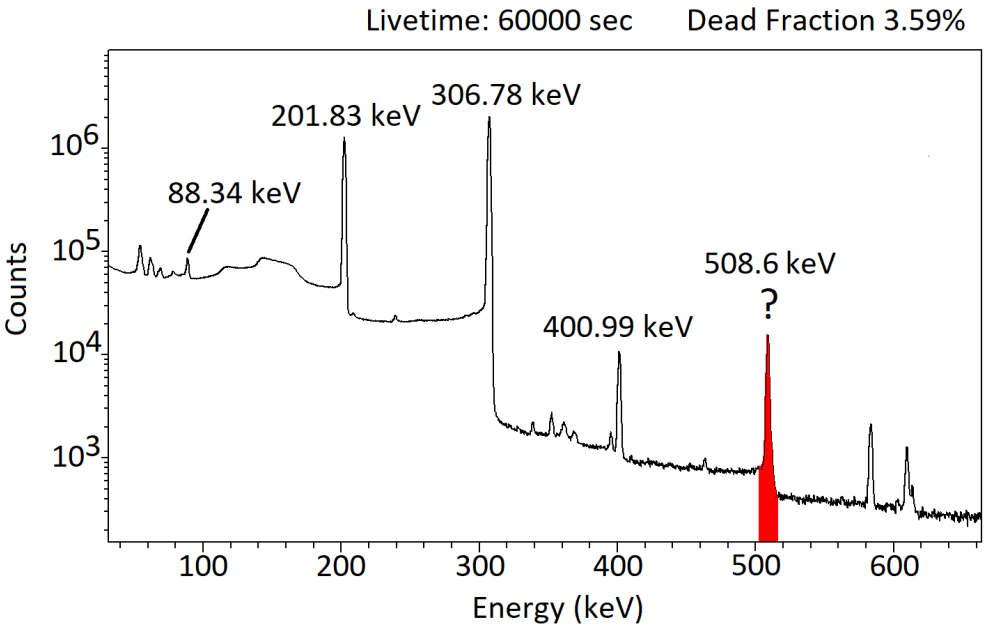
(A) Cf-252
(B) AmLi
(C) AmBe



Question 12: The diagram and spectrum below represent the decay of Lu-176. A peak highlighted in red appears at 508.6 keV. This peak is mostly due to:

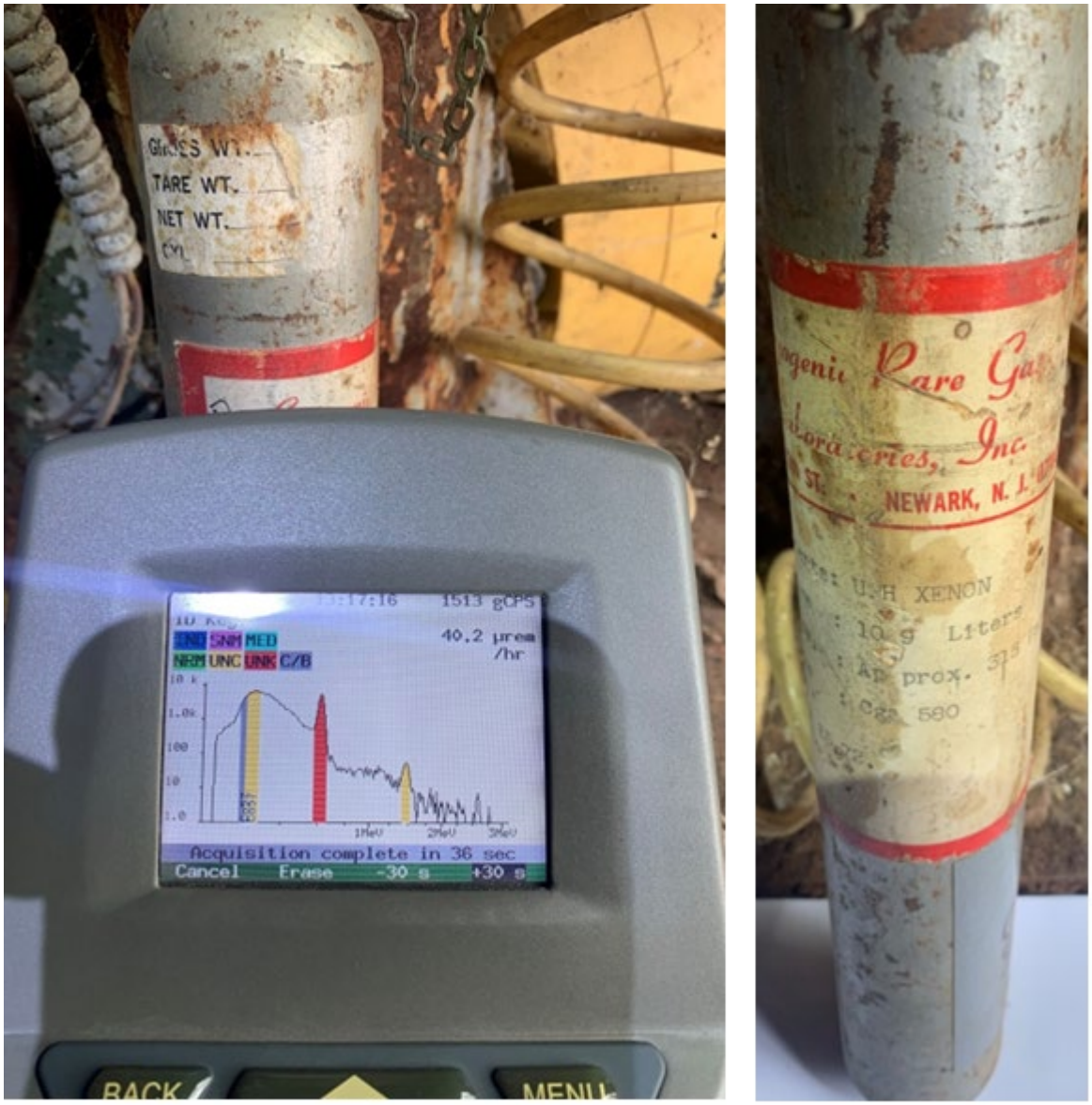
(A) Random (Accidental) Coincidence Summing
(B) Cascade (True) Coincidence Summing
(C) Positron Annihilation





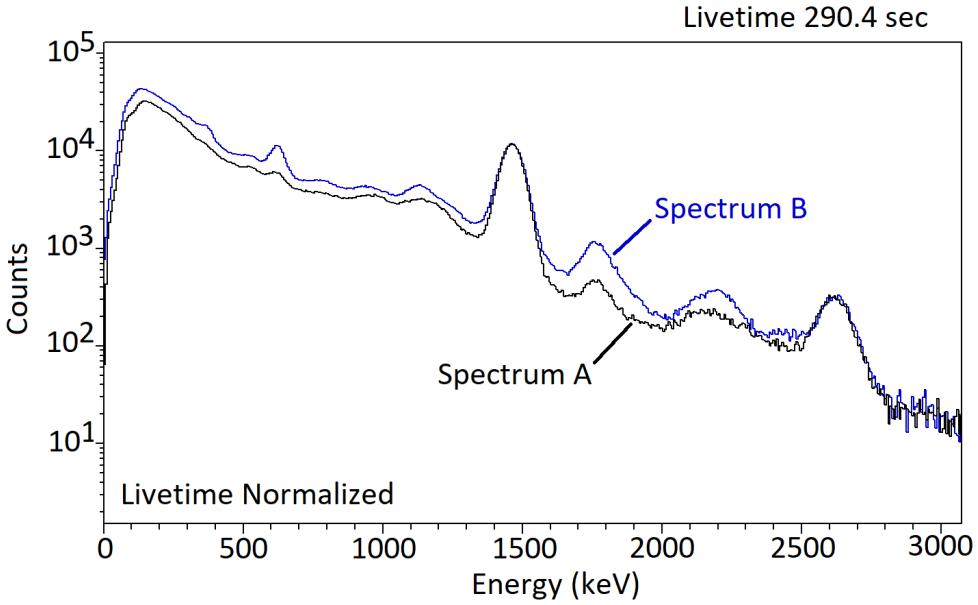
Question 13: This old gas bottle was found in an abandoned warehouse associated with a company that manufactured specialty light bulbs. The spectrum shows peaks at 514 keV and 1460 keV. What radionuclide most likely present in the bottle?

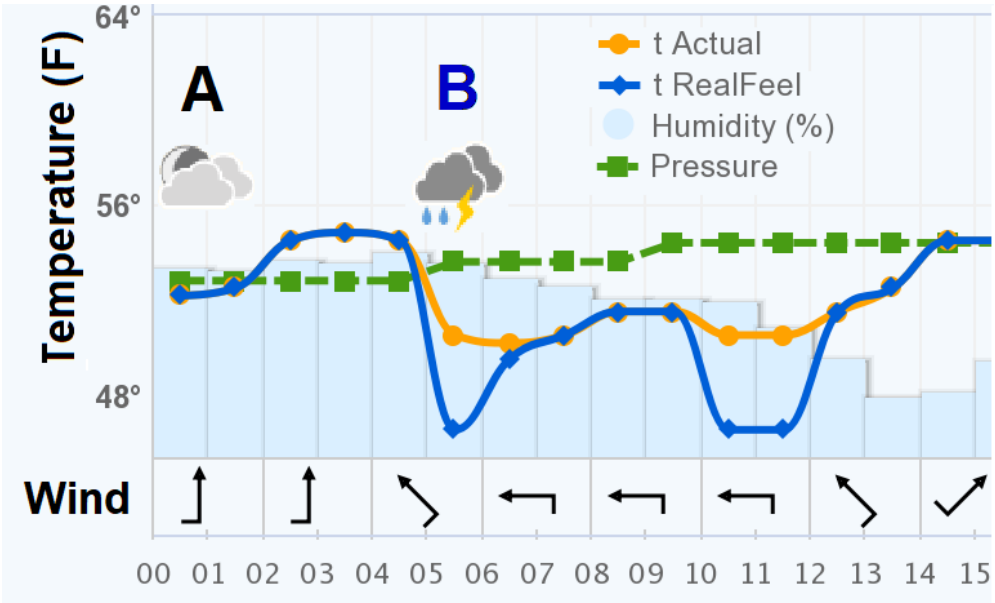
(A) F-18
(B) Na-22
(C) Kr-85
(D) Sr-85



Question 14: The two background spectra shown below were collected in Barcelona, Spain with a large-volume NaI detector. Spectrum A (lower) was collected at 12:10 am before a rainstorm, and Spectrum B (upper) was collected at 5:40 am at the beginning of the rainstorm. Which radionuclide appears to have an activity that depends on the weather?

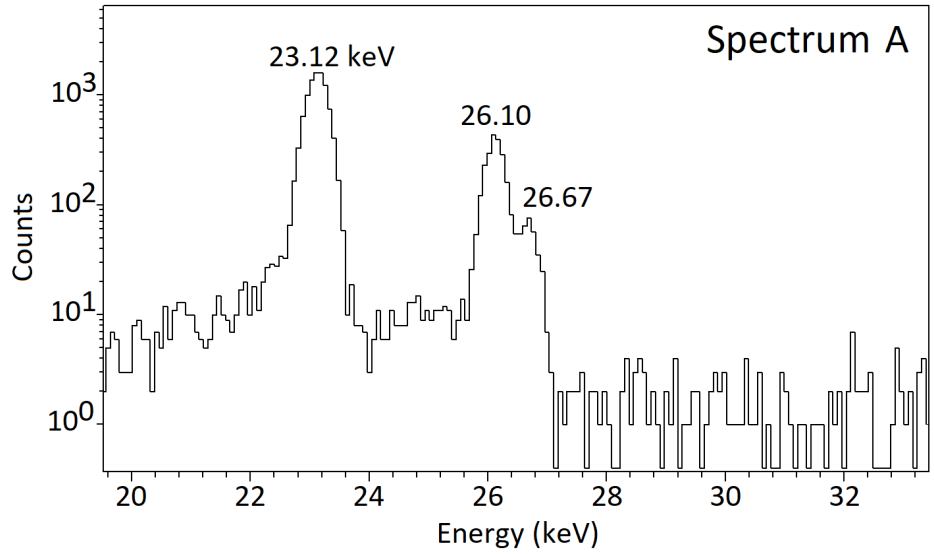
(A) K-40
(B) Rn-222
(C) Th-232

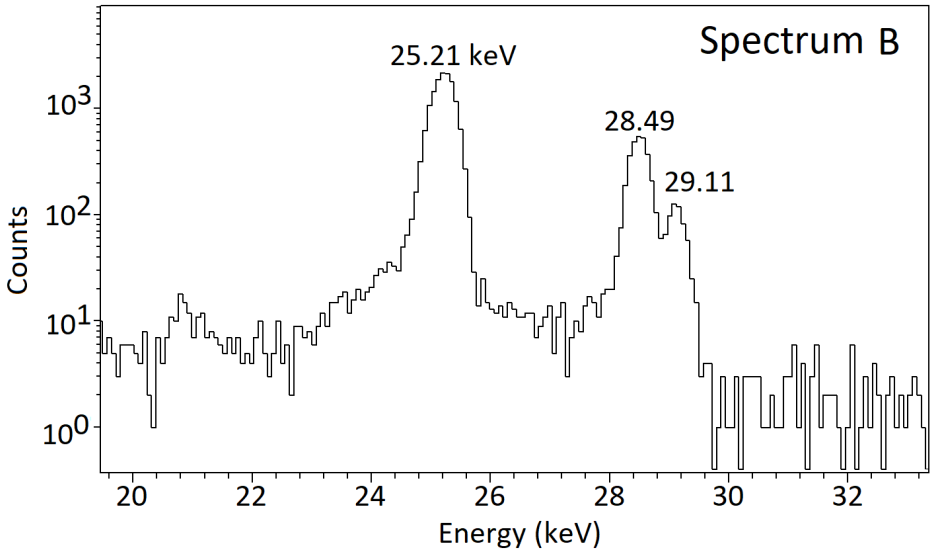




Question 15: One spectrum below shows fluorescent X-rays from cadmium (Cd), and the other spectrum shows fluorescent X-rays from tin (Sn). Fit values for the peaks are shown. Which spectrum shows cadmium (Cd) X-rays?

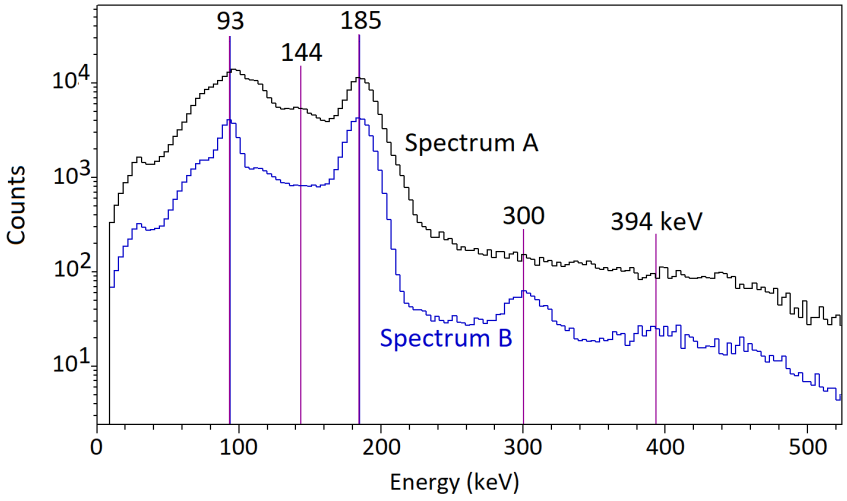
(A) Spectrum A
(B) Spectrum B





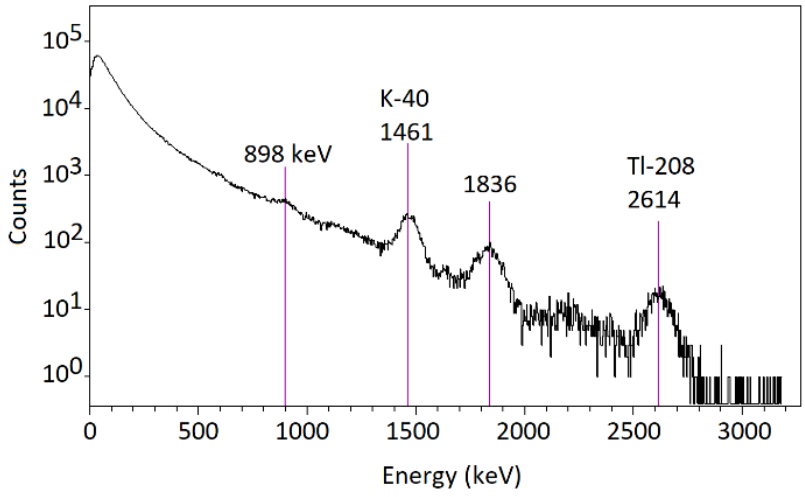
Question 16: The spectra below are collected from highly-enriched uranium (HEU) and Cu-67 using a sodium iodide (NaI) detector. Which spectrum is from HEU?

(A) Spectrum A (upper)
(B) Spectrum B (lower)



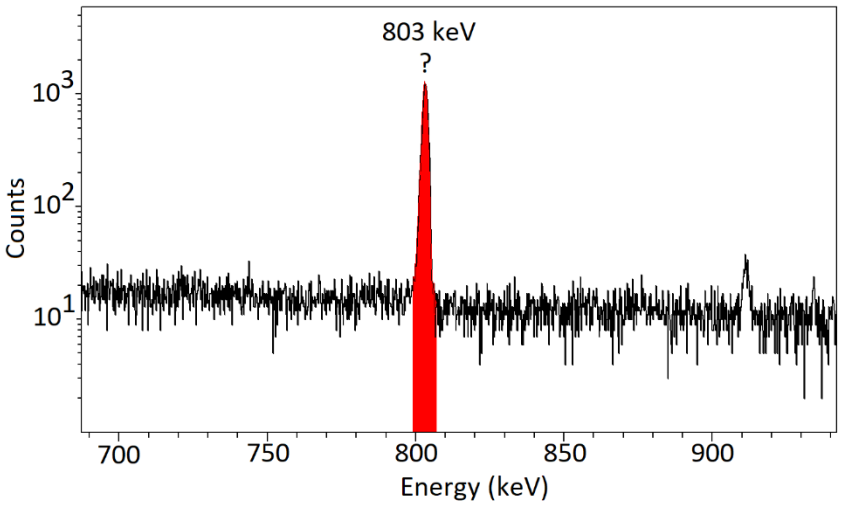
Question 17: This spectrum was collected from a person who had received the radio-pharmaceutical Therasphere™ for treatment of liver cancer. An impurity with a half-life longer than 100 days produces peaks visible at 898 and 1836 keV. What is this impurity?

(A) Eu-154
(B) Ho-166
(C) Tl-207
(D) Y-88



Question 18: The radionuclide shown in the HPGe spectrum below decays by alpha emission, and approximately 0.001% of decays also produce a gamma-ray at 803 keV. It is used in static eliminators, thermoelectric generators, and heaters (especially in spacecraft). It is highly toxic and has been used for homicide. What is this radionuclide?

(A) Am-241
(B) Cs-134
(C) Po-210
(D) Zr-95



Question 19: Where are background gamma radiation levels likely to be higher?

(A) Over the ocean
(B) Over soil

Question 20: Where are background neutron radiation levels likely to be higher?

(A) At sea level
(B) Above 5000 ft

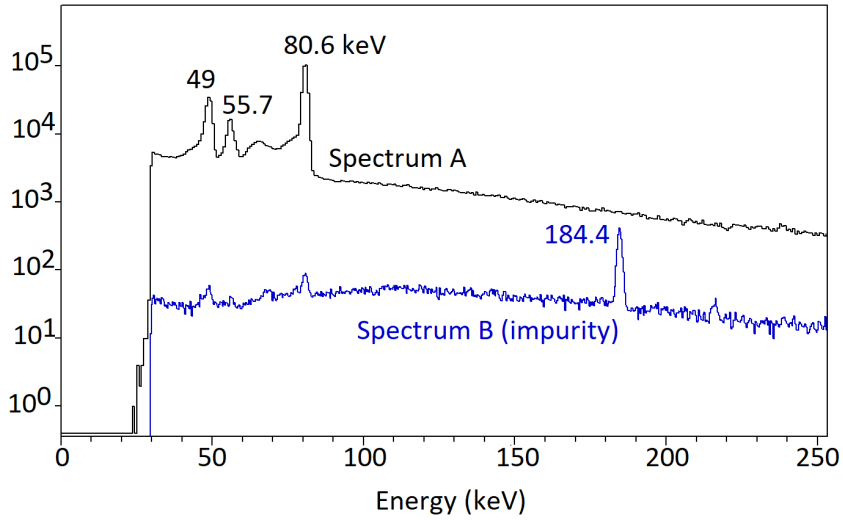
Question 21: The most intense gamma ray from Np-237 comes from its daughter Pa-233. The energy of this gamma ray is:

(A) 212 keV
(B) 312 keV
(C) 412 keV

Question 22: A radionuclide used in a few less-common radiopharmaceuticals emits gamma rays at 80.6 keV and x-rays at ≈49.1 keV and 55.7 keV as shown in Spectrum A below. A metastable impurity with an 184.4 keV gamma may also be present, shown in Spectrum B.

What is the radionuclide shown in Spectrum A?

(A) Ga-67
(B) Ho-166
(C) Lu-177
(D) Tl-201

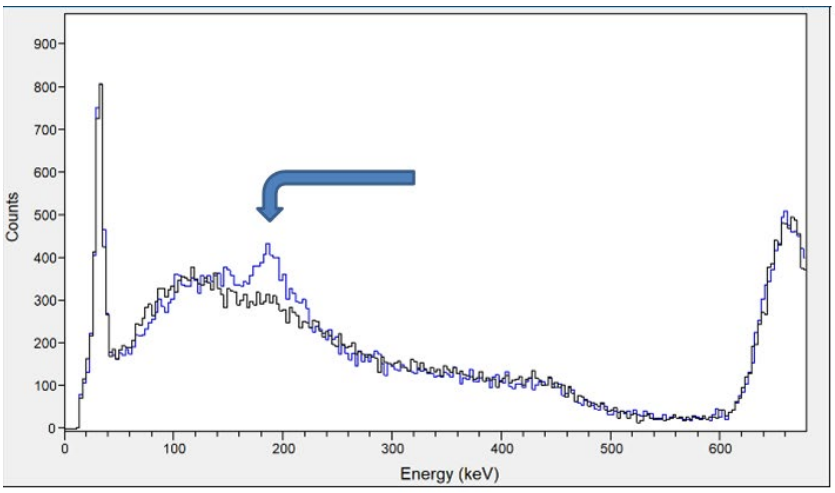


Question 23: Strontium-82 is used as a generator for which isotope?

(A) Ru-82
(B) Rb-82
(C) Kr-82
(D) Br-82

Question 24: The 180° backscatter peak from Cs-137 is most likely to be mis-identified as:

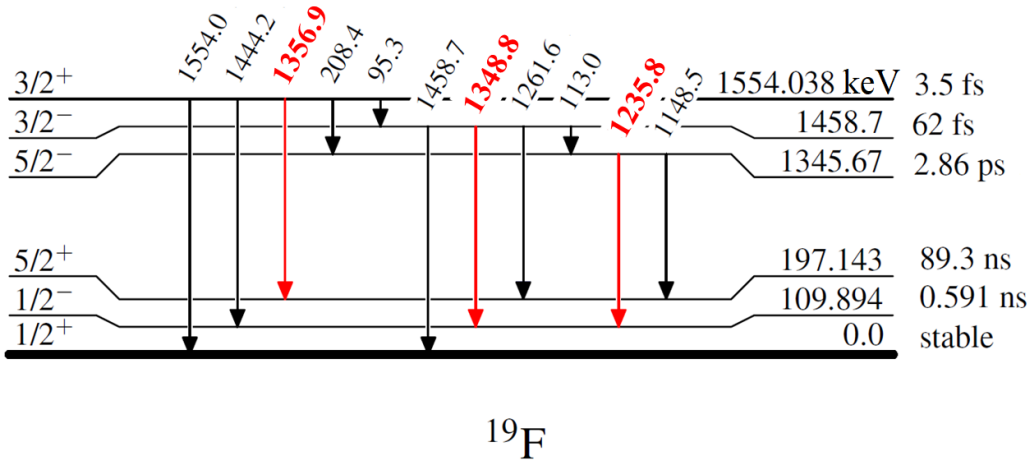
(A) WGPu
(B) HEU
(C) U-233
(D) Np-237



Question 25: Alpha particle interactions with fluorine (F) include 19F(α,n)22Na, 19F(α,α')19F*, and 19F(α,p)22Ne reactions. Some of the resulting signature peaks are Doppler-broadened, and other signature peaks are narrow.

Consider the decay diagram below, which illustrates 19F* excited states that de-excite to produce gamma rays at characteristic energies. The half-lives of the excited states are shown in the rightmost column. Assuming the excitation is due to alpha particle interaction, which gamma ray signature indicated in red is expected to show the LEAST amount of Doppler broadening (producing the narrowest peak)?

(A) 1235.8 keV
(B) 1348.8 keV
(C) 1356.9 keV



^{19}F

The spectrum below was collected from a Pu sample with fluorine impurities.