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Title: DOE Radiological Triage Program Analyst Open Book Exam 2023

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Intended for: Training and Qualification

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DOE Radiological Triage Program Analyst Open Book Exam 2023

Name:________________________________ Date:____________________

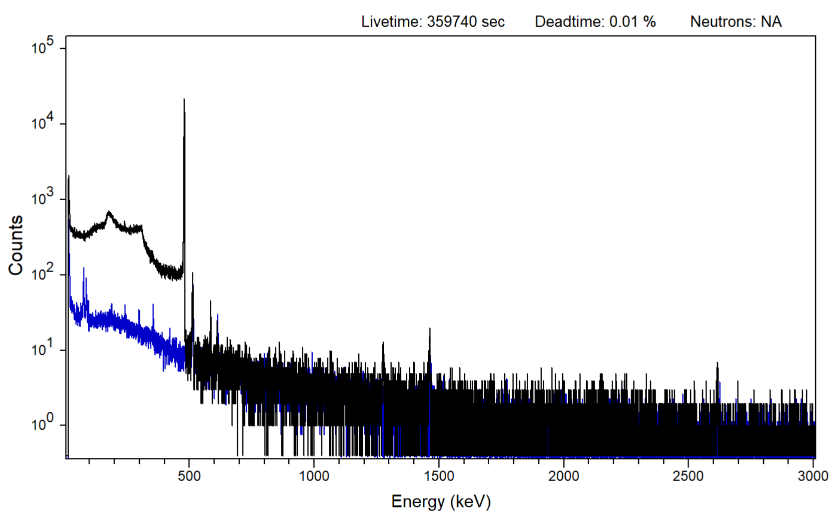
The following questions test your knowledge relevant to the DOE Radiological Triage program. There is no time limit, you may use any reference materials or software you like, and you may discuss with other analysts (provided their exams have not yet been graded). Electronic spectra are provided where relevant. Spectra are provided "as is" with no guarantee of energy calibration.

Please send your answers in any convenient form to Mercer@LANL.gov. A score of 80% is required to pass. There are 10 questions each worth 1 point, and each part of a question receives equal weight. Up to 1 point of extra credit is available.

Question 1: The spectrum "Q1 Filters" shown below was collected using a high-purity germanium detector and a stack of filters removed from a ground-level air monitoring station.

(1a) What cosmogenic radionuclide produces the strong peak below 500 keV?

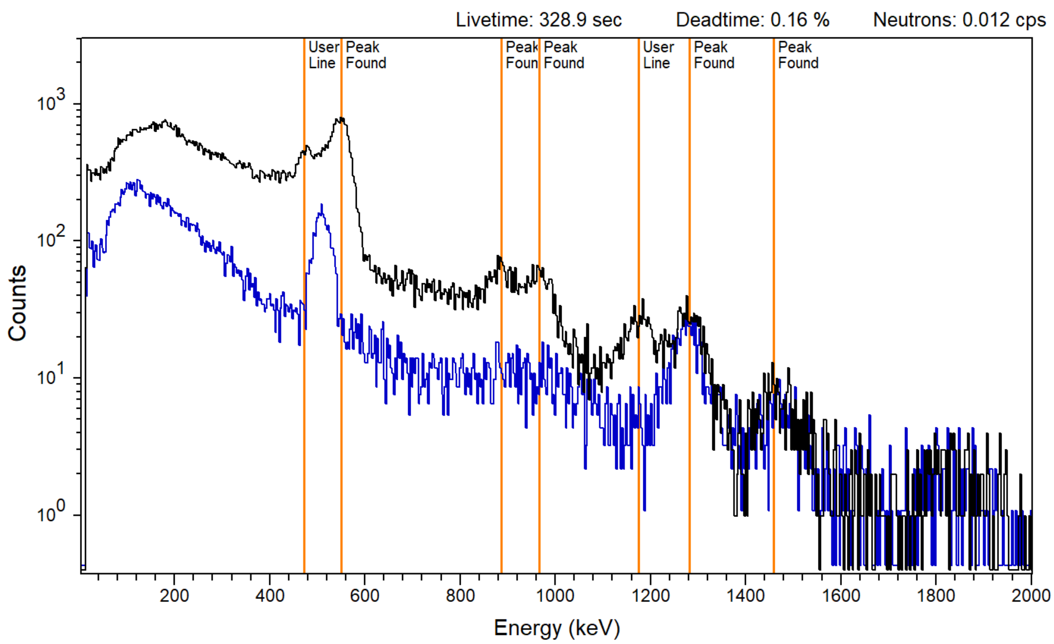
(1b) What other cosmogenic radionuclide is weakly visible?



Question 2: The spectrum "Trial Drug" shown below is collected from a shipment of a radionuclide under study for medical applications (targeted radionuclide therapy). The shipment is apparently shielded so that no gamma rays below 450 keV are visible. The spectrum is from a NaI-based RadSeeker detector with an internal Na-22 calibration source. The background, shown in blue, includes the calibration source.

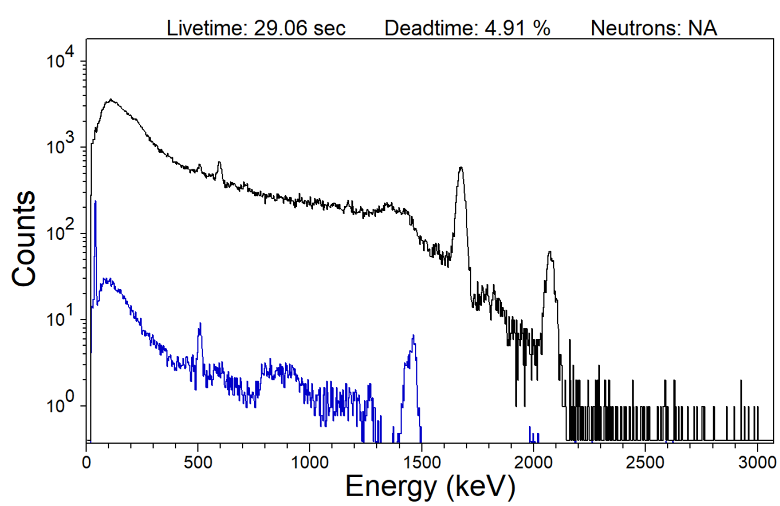
(2a) What radionuclide is evident from the peak at 550 keV?

(2b) The peaks at 879, 966, and 1178 keV are evidence for what radionuclide impurity?



Question 3: Which one of the following radionuclides would be most useful as source of gammas in a 9Be(γ,n)8Be photoneutron source? The threshold gamma energy for the reaction is 1666 keV. Explain your reasoning. The spectrum "Photoneutron" shown below may be useful for checking your answer. This spectrum was collected at a customs inspection station using a LaBr3-based RadSeeker instrument.

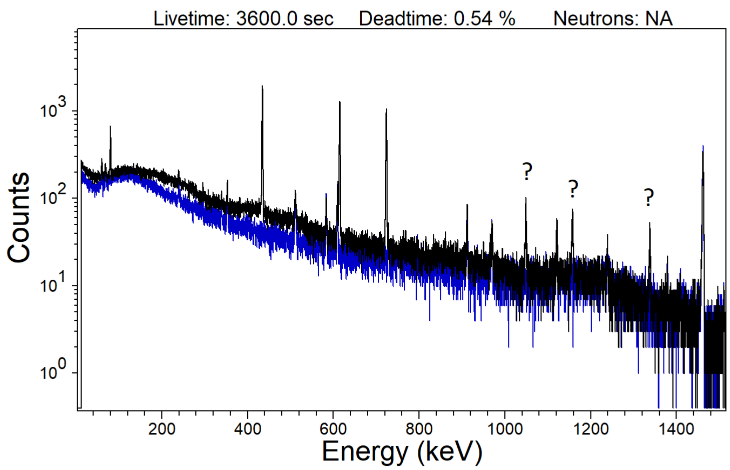
a. 58Co
b. 89Zr
c. 124Sb
d. 154Eu
e. 228Th



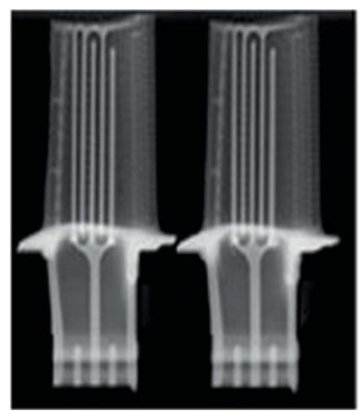
Question 4: The spectrum “Long Metastable” shown below is from a metastable isomer that is a long-lived product of neutron activation.

(4a) What isomer is visible?

(4b) What causes the peaks at 1048, 1157, and 1337 keV?

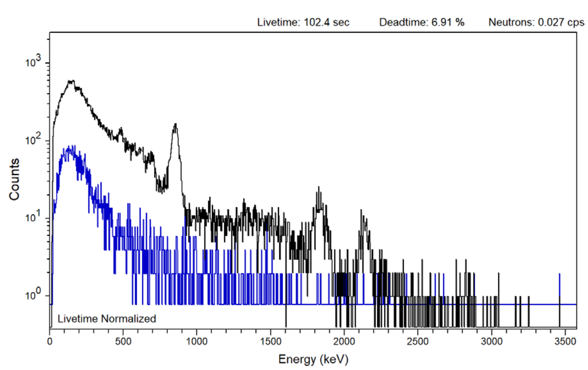


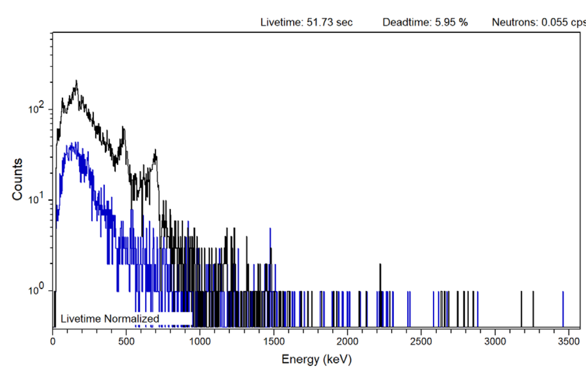
Question 5: A package of aircraft turbine blades is measured with an NaI-based GR-135 instrument after completion of a radiographic inspection. The inspection involved exposure to thermal neutrons.



(5a) The spectrum “Q5 Turbine Blades Early” was measured a few hours after exposure. What radionuclide(s) create(s) the signatures at 847, 1811, and 2113 keV?

(5b) The Spectrum “Q5 Turbine Blades Later” was measured three days after exposure. The configuration may not be identical to the previous measurement configuration. What radionuclide(s) create(s) the signatures at 480 and 686 keV?



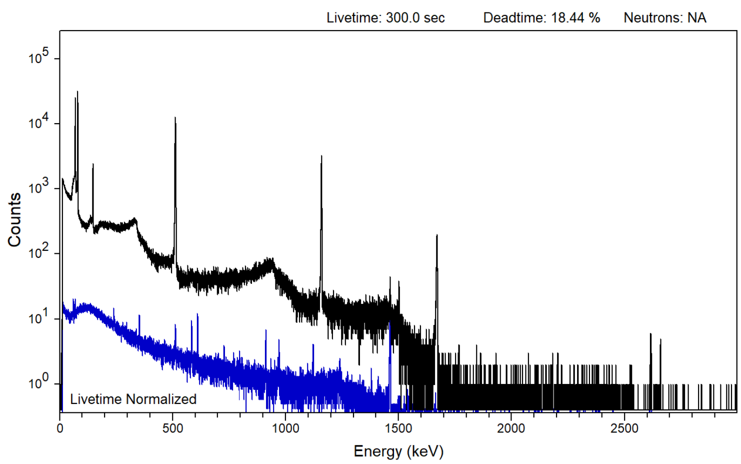


Question 6: The spectrum below shows a radionuclide that is often observed as an activation (spallation) product in stainless steel. This radionuclide is also used as a generator for a positron emission tomography (PET) radionuclide used for medical imaging, although this application is rare. See spectrum “Q6 PET”.

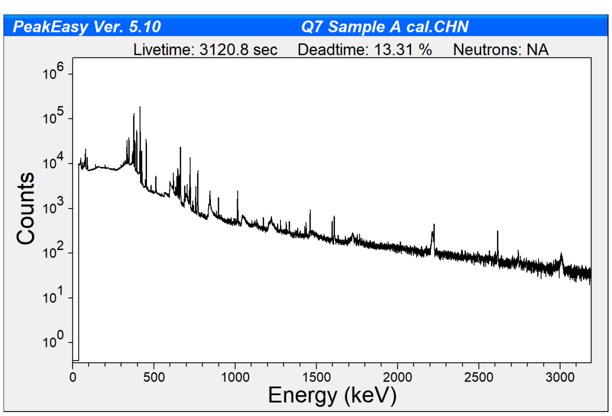
(6a) What parent radionuclide is visible?

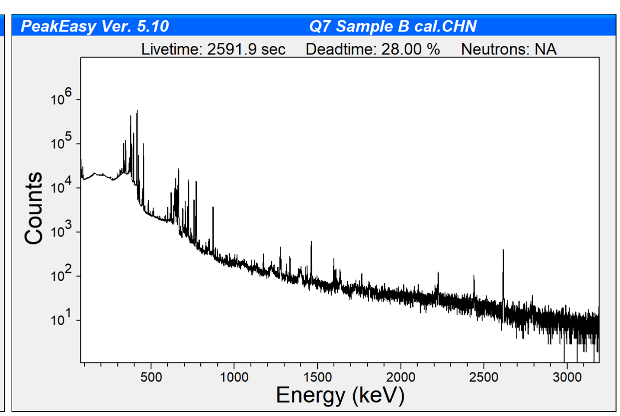
(6b) What decay product radionuclide is visible (useful for PET)?

For 0.2 extra credit points: The decay product radionuclide seems to be entirely in the ground state (4 hour) with no metastable state (57 hour) visible. The metastable state would produce a signature at 271 keV from an isomeric transition, and you can check for yourself that this signature is absent. Why doesn’t decay of the parent radionuclide populate the metastable state?



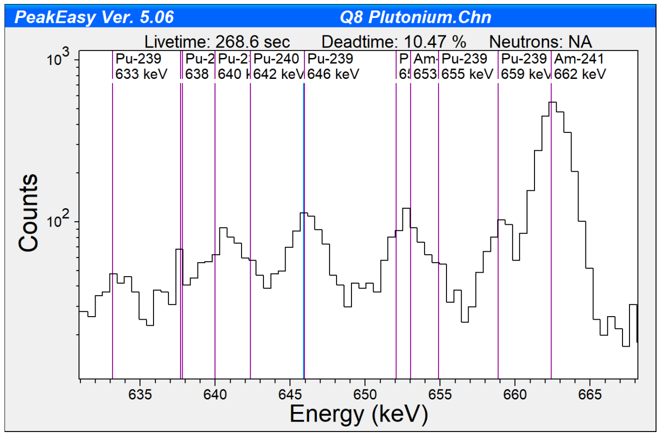
Question 7: The two spectra “Q7 Sample A” and “Q7 Sample B” are of multi-kilogram plutonium items. Which of them is plutonium oxide (PuO_2)? What evidence supports this conclusion?





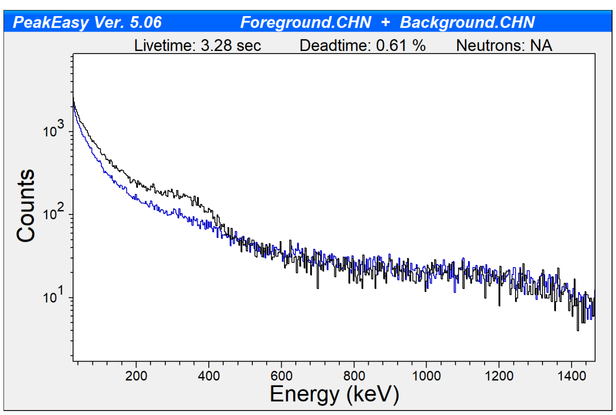
Question 8: An NSTP Team is deployed, and Pu is identified. Based on MC-15 neutron multiplicity data, the NS-TR estimates the Pu-240 mass as 60 to 80 grams. Isotopic analysis estimates the Pu-240 Mass% as 3.9% to 7.5%. Combining these estimates, what is the likely range of total Pu mass?

Don't overthink this; it is not a trick question! There is more than one plausible method, and you will get full credit as long as you show your work. Please use the measured values above. You won't need the spectrum, but it is available as "Q8 Plutonium".



Question 9: A garbage truck was denied entry to a government facility after triggering a portal alarm. The portal monitor is a Symetrica system that uses polyvinyl toluene (PVT)-based gamma detectors. Contextual information suggests a medical isotope. See spectrum "Q9 Garbage Truck".

What is a likely candidate for the medical isotope? Explain.

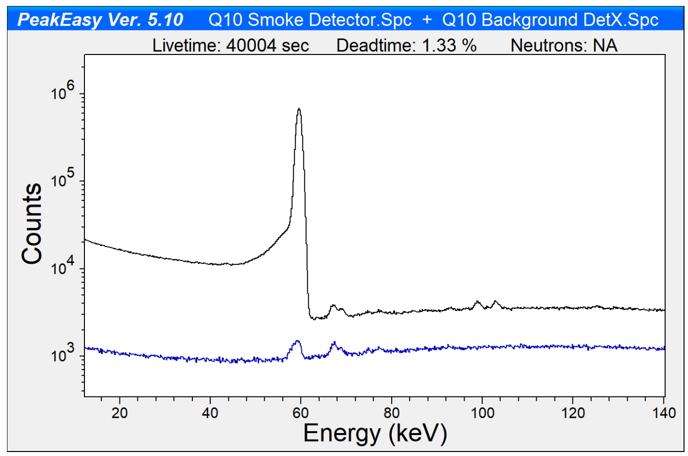


Question 10: The spectrum “Q10 Smoke Detector” was collected using a Detective X at a distance of 3 cm from the face of an ionization-type smoke detector. The body of the item is 4 cm thick as shown. A background, “Q10 Smoke Detector Background,” is available but somehow the live time was not recorded.

(10a) Is the Am-241 shielded or virtually unshielded? What is your evidence?

(10b) Is the activity of Am-241 above or below 1 microcurie (μCi)?

(10c) What collimator material is inside the Detective X pink cap?



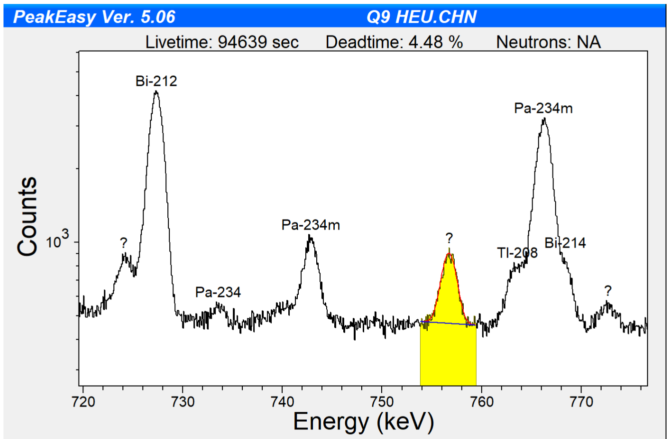
Extra Credit: The spectrum “EC HEU” shows a highly-enriched uranium (HEU) calibration standard that appears to have an impurity radionuclide present. The detector is a planar HPGe that is well-collimated and shielded. Each part is worth up to 0.2 points.

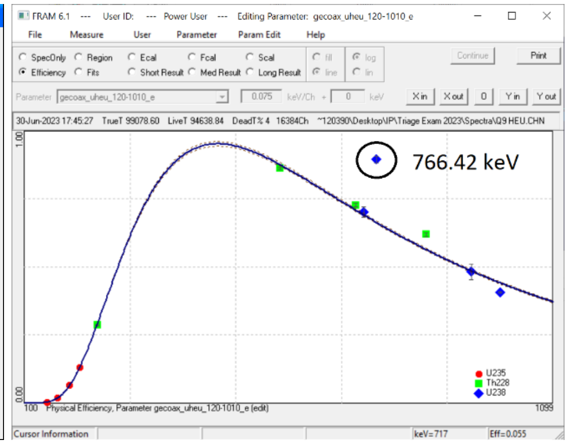
(EC-a) What impurity radionuclide is evident from the peak at 757 keV, highlighted in yellow below?

(EC-b) Explain how this impurity might cause an interference with the nearby 766.42 keV peak, which corrupts the FRAM efficiency curve as shown below (see circled point).

(EC-c) Explain how this impurity might be generated inside a sealed calibration source.

(EC-d) What radionuclide or phenomenon produces the small peak at 773 keV?


PeakEasy Ver. 5.06
Q9 HEU.CHN
Livetime: 94639 sec
Deadtime: 4.48 %
Neutrons: NA
Counts
10^3
Bi-212
Pa-234m
Pa-234
?
Tl-208
Bi-214
720
730
740
750
760
770
Energy (keV)


FRAM 6.1
Editing Parameter: gecoax_uheu_120-1010_e
File
Measure
User
Parameter
Param Edit
Help
766.42 keV
U235
Th228
U238
Physical Efficiency, Parameter gecoax_uheu_120-1010_e (edit)
Cursor Information