TEST 1
Duration: 50 min.

THIS TEST PAPER INCLUDES 6 PAGES and 6 QUESTIONS.

You are responsible for ensuring that your copy of the paper is complete.

Do NOT use cell phone, tablet, laptop or any electronic device.

If you look at other student's exam, your exam would be cancelled out and ZERO MARK would be awarded [NO EXCEPTION !!!].

♦ All work must be shown on this test paper.
♦ Should you run out of space when answering a question, you may use the reverse side of each page if necessary.
1. $^{99}\text{Mo}$ decays as follows:

$$^{99}\text{Mo} \stackrel{t_{1/2} = 66 \text{ hr}}{\longrightarrow} ^{99m}\text{Tc} \stackrel{t_{1/2} = 6 \text{ hr}}{\longrightarrow} ^{99}\text{Tc}$$

(a) What kinds of decays $^{99}\text{Mo}$ and $^{99m}\text{Tc}$ undergo? Briefly explain the reason. (5)

(b) Suppose at time $t = 0$, the activity of $^{99}\text{Mo}$ is 100 Bq and the activity of $^{99m}\text{Tc}$ is 0 Bq. Plot the activity of each radionuclide as a function of time in the time interval of 0 to 200 hours. (5)

(c) When time $t$ passes 60 hours, how does $^{99m}\text{Tc}$ to $^{99}\text{Mo}$ activity ratio vary over time? (5)
2. A $^{197}\text{Au}$ sample is irradiated with a neutron field and the activity of the product for an irradiation time $t$ is given by

$$A(t) = 10^{10} \left(1 - e^{-\frac{\ln 2}{2.7} t}\right) \text{ [Bq]} \quad \text{(Note, } t: \text{ [days]})$$

(a) What is the product nuclide? What kind of decay it undergoes? Briefly explain the reason. (5)

(b) Find the production rate in [s$^{-1}$]. (5)

(c) Find the mean life of the product nuclide. (5)

(d) Plot $A(t)$ as a function of $t$ in the region 0 to 100 seconds. Briefly explain the reason. (5)
3. A point radioactive source was placed at 10 cm from a cylindrical detector with 100 μs dead time and the observed counting rate was $2.4 \times 10^5$ counts/min. Using the extending (paralyzable) model, find the true interaction rate in [s$^{-1}$] at which the observed counting rate is maximum. (10)
4. A 30 min counting for an unknown radioactive sample led to the gross counts of 4,000 counts. The background counts for the same counting time were 3,600 counts.

(a) Compute the net count and its uncertainty. (5)

(b) Find the minimum counting time (hours) required to reach 5% uncertainty for the net counts. (5)
5. From the definition, find the solid angle $[sr]$ for the following detection geometry. (10)