PHYS 102 – Good Nukes, Bad Nukes – Midterm – Fall, '06

This midterm exam is open book, open notes, but you may not collaborate with anyone inside or outside the classroom. You will have the entire 80 minutes of class to complete the exam. Remember that simply stating an answer is not sufficient. You must provide your reasoning or cite your sources. All six questions are equally weighted.

1. $^{60}_{27}$Co undergoes (regular) beta decay with a half-life of 5.27 years. What nucleus remains after a $^{60}_{27}$Co nucleus decays? If you start with a $^{60}_{27}$Co source with an activity of 160 mCi, what will be the activity after 21.08 years?

2. Imagine a person standing five feet away from a pure gamma emitter. Imagine further that the source has an effectively constant activity such that the person would receive a dose of 100 mrads if they stayed in that spot for one hour. What dose would that person receive if they stood in the same spot for only one-half hour? How about if they instead moved to a position ten feet away from the source and stayed there for one-half hour? In this latter case, what would be the person's equivalent dose (in mrem)?

3. Several prominent European scientists fled the European continent in response to the anti-Semitic actions of the governments of Germany and Italy. Name at least two of these prominent scientists and describe their role in the initiation of the atomic bomb project by the US.

4. $^{99}_{43}Tc^*$ is a pure gamma emitter, that is, it emits only gamma rays. It is often used in nuclear medical imaging where it is injected into the body and the resulting gamma rays are observed by detectors placed outside the body. Why would you prefer a gamma emitter in this application as opposed to an alpha emitter or a beta emitter? And why would you prefer a pure gamma emitter as opposed to an isotope that emitted gamma rays in combination with alpha or beta radiation? What nucleus remains when $^{99}_{43}Tc^*$ decays?

5. Calculate the energy change (either released or absorbed) in the reaction

$$ {}^{6}_{3}Li + n^{0} \rightarrow {}^{4}_{2}He + {}^{3}_{1}T $$

Draw a cartoon picture of each of the nuclei involved in the reaction. (This reaction plays a role in fusion weapons, *i.e.*, H-bombs.)

6. What difficulties did the women scientists portrayed in Preston’s book face? Describe how at least one women scientist overcame the obstacles to play a significant role in the development of nuclear science (and describe her role).

Potentially useful facts:

Quality factors:

X-rays, gamma rays, beta rays	1
Alpha rays	20
Neutrons, protons	5-20

1 amu mass difference is equivalent to 931.5 MeV of energy

Masses of isotopes:

n^0	1.008664904	amu
$^{1}_{1}H$	1.007825035	amu
$^{2}_{1}D$	2.014101779	amu
$^{3}_{1}T$	3.01604927	amu
$^{3}_{2}He$	3.01602931	amu
$^{4}_{2}He$	4.00260324	amu
$^{6}_{3}Li$	6.0151214	amu
$^{7}_{3}Li$	7.0160030	amu
$^{8}_{3}Li$	8.022486	amu
$^{9}_{4}Be$	9.0121822	amu