Radiation and Safety, LTT-3306
Examination 27.11.2006

PLEASE ANSWER EACH TASK ON SEPARATE PAPER!

1. What kind of molecular changes does radiation induce in cell? How do the effects of photon radiation and of electron radiation differ from each other? How can the molecular damage lead to hazardous health effects?

2. List three (different) methods for detecting radiation and briefly explain the principles of each of them.

3. Tell about diagnostic reference levels and their use in radiology.

4. An employee has to work long times in a laboratory room. There is a bottle of 131-I with activity of 100 MBq (Half-life 8 d, most common gamma energy 364 keV, HVL in lead 3.3 mm) on the shelf in the room. The employee protects him/herself from radiation by the following means:
   a) He/She decreases the time in laboratory by doing the work in half of the original time.
   b) He/She puts the isotope into a lead container with wall thickness of 1 cm.
   c) He/She moves the bottle so that the distance is 2 m instead of 1 m.

   Estimate roughly numerically the effectiveness of used shielding methods. Please explain your calculation.

You can utilize your points from the exercises in either of the following calculation tasks.

5.

Isotope	Decay form	$T_{1/2}$ [s]	M [g/mol]	m [g]	ρ [kg/m^3]
$^{15}O_8$	β^+	122	15	5.0	1,43
$^{220}Rn_{86}$	α	56	220	5.0	9,73

N_A=6,022*10^{23} 1/mol

At time moment t=0 s you have two isotopes, oxygen-15 and radon-220. The mass of both isotopes is 5.0 g.

a. Describe how they decay as $^A X_Z \rightarrow$?. You can mark the born nuclide with "Y" if you don't have the periodic table. Name the particles.
b. What are the activities of oxygen and radon at t=0 s?
c. What are their activities after t=5000 s?
d. After what time t, the activity of radon is the same as for oxygen after 5000 s (the activity from the previous calculation)?

6. In the radiation therapy department an old low energy linear accelerator (4 MV) was replaced by a higher energy (20 MV) accelerator. The output of the new accelerator at 1 m distance from the radiation source is 4 Gy/min. When the radiation beam is directed towards the wall, behind which the control room is located, the distance from the radiation source to the wall is 4.4 m. The thickness of the concrete wall is 1.6 m. The momentary dose rate outside the wall may not exceed 15 μSv/h. Is additional steel shielding in the wall needed? If yes, how thick of a plate of steel? ($TVL_{concrete}$ =40.0 cm and TVL_{steel} =10.5 cm for 20 MV X-rays.)