Radiation and Safety LTT-3306
Examination 22.1.2007
6 questions

1. Describe the interaction mechanisms between electromagnetic radiation and matter. List **at** least **three** (3) mechanisms.

2.
   a. Explain **briefly the** direct and indirect effect of ionizing radiation in molecular level in a living cell. **2 points**

   b. Describe **briefly** the deterministic and stochastic adverse effects caused by exposure to ionizing radiation. **4 points**

3. Tell about the basic principles of radiation protection and their implementation in radiology.

4. The activity of 18-F isotope is 400 MBq in the morning at 8.00 o'clock. The isotope is in an unshielded bottle. Estimate the radiation exposure of a person working behind a thin wall at 3 m distance; exposure time is from 8 to 16 o'clock. 18-F has a half-life of 110 min and it sends 511 keV gamma radiation with production factor of $1,9*10^{-4}$ mSv/MBq in one metre distance per hour.

SEE NEXT PAGE!

In case this is the first exam that you are attending, you may replace one of the following calculation tasks (lower score) by the points from the exercises. If this is your second exam, the exercise points are not valid anymore.

5.

Radiation type	**Weighting factor w_R**
Photons, all energies	1
Electrons and myons, all energies	1
Neutrons with energy	
<10keV	5
10keV<E<100keV	10
100keV<E<2MeV	20
2MeV<E<20MeV	10
>20Mev	5
Protons, energy >2MeV	5
Alpha particles, fission fragments, heavy nuclei	20

Tissue or organ	**Weighting factor w_T**
gonads (testes or ovaries)	0,20
red bone marrow, colon, lungs, stomach	0,12
bladder, breast tissue, liver, oesophagus, thyroid gland	0,05
skin, bone surface	0,01
other tissues and organs*	0,05

*adrenal, brain, upper large intestine, small intestine, airways outside thorax, kidney, muscle, pancreas, spleen, thymus and uterus.

$H_T = \sum_R w_R D_{T,R}$

a. What is the equivalent dose for photons if the absorbed dose is 1,25 Gy?

$E = \sum_T w_T \sum_R w_R D_{T,R}$

b. What is the effective dose for photons in lungs if the absorbed dose is 1,25 Gy?

c. What is the effective dose for alpha-radiation in ovaries if the absorbed dose is 1,5 Gy?

d. If both radiation types and both targets are valid simultaneously, what are the equivalent doses and what is the effective dose?

e. Which ones (lungs/ovaries) are more sensitive to radiation and why?

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.)

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 $^AX_Z \rightarrow$?. 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)?

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