PHYS-450: Radiation Biology, Protection and Applications

Example Written Exam Questions + Solution

SECTION A
Questions with one answer, 2 points per question.
Please circle the correct answers.

Question 1:
e) The photoelectric effect is important only at high energies (>1 MeV).

Question 2:
a) It is the scattering of a photon off a charged particle.

Question 4:
b) 2

Question 5:
c) 7.40 MeV

Question 6:
a) The measurement of an absorbed dose (Gy).

Question 8:
c)

Question 9:
d)

Question 21:

A lab worker receives an average monthly effective dose of 1.5 mSv during 45 years of professional work:

a) The total effective dose of 810 mSv will provoke blood alterations and first deterministic effects. TRUE **FALSE**

b) The exposure will provoke a slow but steady deterioration of the eye lens transparency and eventually eye lens surgery will become necessary. TRUE **FALSE**

c) Only the first symptoms of radiation sickness, nausea and vomiting, may appear. The dose does not exceed the limits where symptoms as diarrhea, dizziness etc. can be observed. TRUE **FALSE**

d) We expect bloody vomit and stools from internal bleeding due to the incorporation of high radionuclide activities. TRUE **FALSE**

Question 27:

Statements:

a) Radioisotopes used in diagnostic medicine are usually gamma emitters. **TRUE** FALSE

b) *Ion pair* formation involves the *nonchemical* removal of electrons from atoms to form ions. **TRUE** FALSE

c) In beta decay the parent and daughter nuclides have the same mass number. **TRUE** FALSE

d) A *free radical* is a highly reactive uncharged part of a molecule that contains an unpaired electron. **TRUE** FALSE

Question 30:

d) β^{+} *and* ν

Question 31:

Why does radiation with a linear energy transfer (LET) of 100 keV/µm have the greatest relative biologic effectiveness for cell killing, mutagenesis, or oncogenic transformation? Which type of radiation (α, β, γ, n, ions) is likely to reach such an LET?

High local ionization density. **The average separation between ionizing events approaches the diameter of the DNA double helix (i.e., about 2 nm), thus resulting in a higher probability of e.g. double-strand breaks for a given absorbed dose.**

Ions > alpha > n > beta > gamma

Question 37:

Radionuclide batteries: describe **three** existing methods for the conversion of the decay energy to electric energy. **What radionuclide types are frequently used?**

For the conversion of the decay energy to electric energy several methods exist (overview):

Direct conversion by use of charged potentials or by betavoltaic conversion (or alpha voltaic conversion).

Indirect conversion is mostly based on thermoelectric conversion consisting of 2 steps: decay energy is transformed to heat, which is transformed to electric energy by a thermoelement (SEEBECK-effect).

Other indirect methods involving two steps are: thermionic, thermophotovoltaic or photoelectric conversion.

Radionuclides decaying by subsequent emission of several α particles, such as ^{238}Pu and ^{232}U, are most favorable.

Question 38:

Briefly discuss three industrial applications using α, β-particles, γ-rays, protons and/or neutrons of your choice. What are the physical basics of those applications? If applicable, what radionuclides are usually used for those applications?

Food irradiation
Sterilization
Radionuclide batteries
Scatter camera
SPECT
Radiotherapy
... etc.