

PHYS-450: Radiation Biology, Protection and Applications

Example Written Exam Questions

SECTION A

Questions with one answer, 2 points per question.

Please circle the correct answers.

Question 1:

Which of these statements is NOT one of the main characteristics of the photoelectric effect?

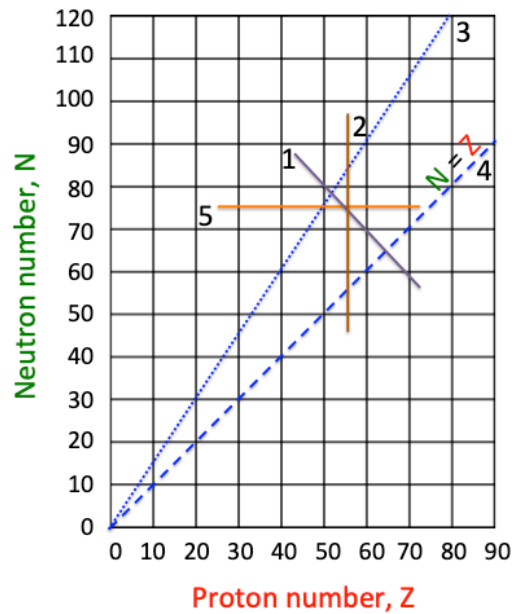
- a) The photoelectric effect is strongly dependent on the material atomic number (Z).
- b) The photoelectric effect is important at low energies.
- c) The photoelectric effect is related to electron binding energies in the atoms.
- d) The photoelectric effect is a fundamental effect for radiography.
- e) The photoelectric effect is important only at high energies (>1 MeV).

Question 2:

What is the Compton effect?

- a) It is the scattering of a photon off a charged particle.
- b) It is the same as the photoelectric effect.
- c) It is the creation of an electron/positron pair inside the nucleus.
- d) It is the physical process for the production of Bremsstrahlung.
- e) It is the physical process for the beta plus decay.

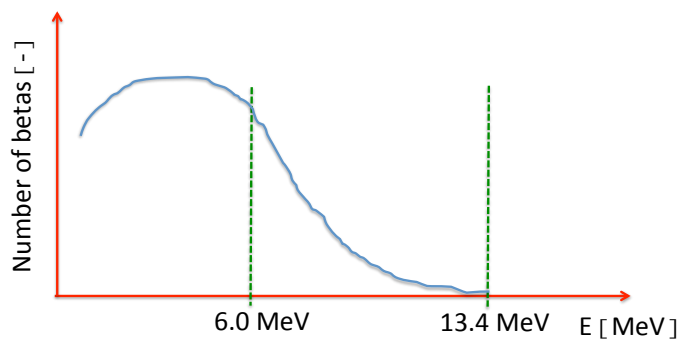
Question 4:



Two nuclides that are isotopes of the same element lie on curve No. ...

- a) 1
- b) 2
- c) 3
- d) 4
- e) 5

Question 5:



The beta spectrum for ^{12}B decay is shown in the graph above. The kinetic energy of an emitted beta particle was measured to be 6.00 MeV. The energy of the associated antineutrino is approximately ...

- a) 6.00 MeV
- b) 13.40 MeV
- c) 7.40 MeV
- d) 11.30 MeV
- e) 2.54 MeV

Question 6:

For what kind of measurement would you recommend a TLD detector?

- a) The measurement of an absorbed dose (Gy).
- b) The measurement of surface contamination (Bq/cm²).
- c) The measurement of air contamination (Bq/cm³).
- d) The measurement of an activity (Bq).
- e) The measurement of source/radionuclide identification (gamma energy in eV).

Question 8:

Bricks are used to attenuate a gamma ray beam. Two bricks reduce the intensity to half of the initial value (no brick shielding). Choose the correct statement.

- a) Four bricks would reduce the intensity to 12.5% of the initial intensity.
- b) Six bricks would reduce the intensity to 25% of the initial intensity.
- c) Eight bricks would reduce the intensity to 6.25% of the initial intensity.
- d) Three bricks would reduce the initial intensity to 25% of the initial intensity.
- e) Ten bricks would reduce the intensity to less than 1% of the initial intensity.

Question 9:

What happens after a cell is damaged by radiation?

- a) There is a high probability to develop a cancer.
- b) The cell loses functionality and dies.
- c) It induces radiation sickness (e.g. vomiting, diarrhea, headache, dizziness and disorientation).
- d) The organism attempts to repair the damage and, if successful, the cell survives.
- e) The organism induces cell apoptosis in any case.

SECTION B

TRUE / FALSE questions, 4 points per question.

Please circle the correct answers.

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:

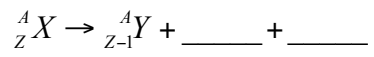
Statements:

- 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

SECTION C

Question 30:

- In the following decay scheme:



the blanks should contain

- a) β^+ and n
- b) β^- and ν
- c) β^- and p
- d) β^+ and ν

Please circle the correct answer.

SECTION D

Open questions, 4 points per question.
Calculate, describe, discuss, sketch ...

Question 31:

Why does radiation with a linear energy transfer (LET) of $100 \text{ keV}/\mu\text{m}$ 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?

Question 37:

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

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?