

Practice multiple choice exam.

- 1 An activity of 1 millicurie (1 mCi) equals:
 - a) 37 kBq
 - b) 37 MBq
 - c) 37 GBq
 - d) 37 TBq

- 2 The specific activity of a pure (carrier free) radionuclide is proportional to:
 - a) the molar mass M
 - b) the half value time $T_{1/2}$
 - c) the decay constant λ
 - d) the density ρ

- 3 What is the minimal thickness of Perspex β -glasses (density = $1.2 \text{ g}\cdot\text{cm}^{-3}$) in order to shield all β - particles emitted by an unshielded ^{32}P source ($E_{\beta\text{-max}} = 1.71 \text{ MeV}$)?
 - a) 0.25 cm
 - b) 0.36 cm
 - c) 0.75 cm
 - d) 1.0 cm

- 4 Which fraction of the energy of β - particles emitted by an unshielded ^{32}P source ($E_{\beta\text{-max}} = 1.71 \text{ MeV}$) is converted to bremsstrahlung (on average) when the particles are completely decelerated in Perspex ($Z_{\text{eff}} = 6$).
 - a) $6\cdot 10^{-4}$
 - b) $2\cdot 10^{-3}$
 - c) $2\cdot 10^{-2}$
 - d) $5\cdot 10^{-2}$

- 5 Which interaction mechanism of photons with matter is most dominant for narrow beam X-rays generated at 200 keV attenuated in lead?
 - a) Photo-electric effect
 - b) Compton effect
 - c) Pair production
 - d) Coherent (Rayleigh) scattering

- 6 When regarding the interaction of photons with matter, one usually distinguishes four linear attenuation coefficients, denoted by the symbols μ , μ_{en} , μ_{a} and μ_{tr} . Which of the following statements is **false**?
 - a) Of these four, μ has the highest value at a given photon energy and material.
 - b) μ_{en} is used for calculations on the absorbed dose.
 - c) μ_{tr} and μ_{en} are numerically the same at a given photon energy and material, for light materials and low energies.
 - d) μ_{a} is mostly used for shielding calculations.

- 7 For photons with an energy of 1.5 MeV the mass attenuation coefficient μ/ρ in a material (density ρ , atom number Z and molar mass M) is approximately
- proportional to M
 - proportional to Z
 - inversely proportional to Z
 - independent of Z and M
- 8 Which of the following materials has the biggest cross section for thermal neutron capture?
- cadmium
 - paraffin
 - water
 - uranium-235
- 9 Approximately how much energy is absorbed in 100 cm^3 of air (normal temperature and pressure) at an air Kerma of $1 \mu\text{Gy}$?
- 10^{-6} J
 - 10^{-8} J
 - 10^{-10} J
 - 10^{-13} J
- 10 Charged particle equilibrium exists in a point P of a photon irradiated medium if:
- the secondary particles with opposite charge are in equilibrium in the volume surrounding P .
 - the dimensions of the medium surrounding P is at least as large as the range of the most energetic secondary particles.
 - for every charged particle entering or leaving the volume surrounding P , another particle with opposite charge leaves or enters the volume surrounding P .
 - for every charged particle leaving the volume surrounding P , another charged particle of the same type, charge and energy enters the volume surrounding P .
- 11 The radionuclide ^{24}Na emits γ -radiation ($E_\gamma = 1.37$ and 2.75 MeV , yield of both = 100%) as well as β -radiation ($E_{\beta, \text{average}} = 0.55 \text{ MeV}$, yield = 100%) What is the dose rate in tissue at 0.1 m from an unshielded ^{24}Na point source of 1 MBq ?
- $\sim 25 \mu\text{Gy/h}$
 - $\sim 0.15 \text{ mGy/h}$
 - $\sim 1 \text{ mGy/h}$
 - $\sim 15 \text{ mGy/h}$
- 12 Which of the following dosimetric quantities is an **operational** quantity?
- effective dose, E
 - equivalent dose, H_T
 - collective effective dose, S_E
 - personal dose equivalent $H_p(d)$

- 13 The ambient dose equivalent $H^*(d)$ in a point in a radiation field is:
- a) a primary physical dosimetric quantity
 - b) an operational dosimetric quantity, that can be used as an indicator for the effective dose E and the equivalent dose H_T
 - c) the dose equivalent in soft tissue at a depth of d mm under the specified point on the body
 - d) the dose equivalent, calculated for the organs at a depth d mm in the body
- 14 Which of the statements concerning the biological effect is **false**?
- a) above the threshold the severity of the deterministic effects increases with the dose
 - b) the chance that deterministic effects occur in a certain individual is independent of the dose
 - c) repair mechanisms after irradiation play a role in the chance that stochastic effects occur
 - d) at low doses and a low dose rate, the ICRP assumes a linear relationship between the dose and the chance that stochastic effects occur
- 15 Which of the following biological effects of radiation is **not somatic**?
- a) deformation of children as a result of mutated reproductive cells of the parents
 - b) permanent sterility
 - c) hair loss
 - d) leukaemia
- 16 Which radiation effect, according to current opinion, has the highest chance of occurring after instantaneous exposure of the whole body to low LET radiation at a dose of 0.1 Gy?
- a) erythema
 - b) permanent sterility
 - c) hair loss
 - d) leukaemia
- 17 In the publications of the ICRP (ICRP-60, 1991) an average risk factor for the occurrence of a radiation induced fatal cancer in the **working population** is used for radiation protection purposes. The value, per Sv effective dose, of this factor is:
- a) 1.25 %
 - b) 1.65 %
 - c) 4 %
 - d) 7.3 %
- 18 The tissue weighting factors w_T for tissues and organs T that the ICRP advises in the ICRP-60:
- a) give the contribution of T in the total detriment for a homogenous irradiation of the whole body
 - b) indicate the relative importance of T for the functioning of the whole person
 - c) give a correction for the differences in mortality for stochastic effects in the different tissues and organs
 - d) give a correction for the differences in mass of the different tissues and organs

- 19 The annual dose limit for exposed workers as recommended in the ICRP-60 is:
- 20 mSv/year
 - 20 mSv/year, averaged over defined periods of 5 years
 - 20 mSv/year, averaged over defined periods of 5 years however no more than 50 mSv in a single year
 - 50 mSv/year, however no more than 20 mSv/year averaged over the whole occupational life
- 20 When an exposed worker, class A, receives an effective year dose of 15 mSv, then this is allowed if:
- the ALARA principle was met.
 - the ALARA principle and the justification principle were met.
 - the justification principle was met.
 - the year dose in the following five years is lower than 5 mSv.
- 21 Which of the sources hereunder gives the highest contribution in the average annual effective dose per member of the Dutch public, except for average medical exposure?
- exposure caused by man-made sources and residual activity from nuclear tests and incidents
 - cosmic radiation and external terrestrial radiation sources
 - ^{40}K and ^{14}C in the body
 - radon and its decay products
- 22 A nuclide with a physical half life of 7 hours has a biological half life in a certain organ of 14 hours. What is the total number of nuclear transformations (in Bq·s) between time $t=0$ and $t=1$ month, if the activity at $t=0$ in the organ is 1 kBq?
- $6.7 \cdot 10^3$
 - $2.4 \cdot 10^7$
 - $7.6 \cdot 10^7$
 - $1.1 \cdot 10^8$
- 23 In the ICRP-lung model (ICRP-66) three types are distinguished for absorption in the blood of radioactive aerosols: **Fast**, **Moderate** and **Slow**. The biological half life for the absorption of **type F** aerosols from the part of the respiratory system in the thorax is by default equal to:
- 10 minutes (100%)
 - 10 minutes (50%) and 10 days (50%)
 - 10 minutes (10%) and 10 days (90%)
 - 10 minutes (10%) and 140 days (90%)
- 24 Which of the quantities underneath does **not** play a role in determining the equivalent dose H_T in an organ or tissue T, as a result of the uptake of a certain radionuclide in T?
- the tissue weighting factor w_T
 - the radiation weighting factor(s) w_R of the emitted radiation
 - the mass of T
 - the physical half life of the radionuclide

- 25 A radiation detection system can not be influenced by consecutive interactions after the first interaction during a 'dead time' of 100 μs . In a certain radiation field, the system displays 1000 counts per second (cps). What is the "real" count rate after dead time correction?
- a) 900 cps
 - b) 1010 cps
 - c) 1111 cps
 - d) 2000 cps
- 26 A radiation detection system with a Geiger-Müller detector with a thin window is **not suitable** for measuring
- a) contaminations of α -emitters ($E > 5 \text{ MeV}$)
 - b) contaminations of β -emitters ($E > 0.5 \text{ MeV}$)
 - c) the kerma rate of photon radiation ($E > 0.1 \text{ MeV}$)
 - d) the energy spectrum of photon radiation ($E > 0.1 \text{ MeV}$)
- 27 Portable monitors for the detection of the exposure or air kerma rate as a result of photon radiation, usually contain a Geiger-Müller tube surrounded by a metal casing. The most important function of this casing is
- a) protection of the GM-tube against damaging and dirt
 - b) shielding the GM tube from electro magnetic interference
 - c) increasing the detection efficiency of the GM-tube for low energy photons
 - d) correction of the too high response of the GM-tube in the energy range up to 0.2 MeV, as a result of the photo effect in the cathode material with a high Z
- 28 Which of the materials below is often used in neutron detectors for moderation (slowing down) of neutrons, in combination with a separate detector for slow neutrons?
- a) polyethylene
 - b) boron
 - c) cadmium
 - d) lithium
- 29 A **narrow beam** mono-energetic photon radiation is attenuated by a factor 10^3 in 10 cm lead. How much lead is needed for a transmission of a factor 10^{-5} for a **broad beam** of the same radiation?
- a) 13 cm
 - b) 19 cm
 - c) 25 cm
 - d) 35 cm

- 30 For a narrow beam with a set photon energy in the energy range where the Compton effect is dominant (at a first approximation)
- a) the thickness of a shield, required for a certain attenuation, is equal for all materials
 - b) the mass thickness (in kg/m^2) of a shield required for a certain attenuation, is equal for all materials
 - c) the half value layer (in m) is equal for all materials
 - d) the linear attenuation coefficient is equal for all materials
- 31 In the directive Radionuclide laboratories (Dutch legislation) a 'design value' is assumed for the maximal annual effective dose for the exposed workers. All safety measures in the lab are designed to meet this value during normal working conditions. This value is
- a) 0.1 mSv
 - b) 0.5 mSv
 - c) 2 mSv
 - d) 5 mSv
- 32 In a well equipped C-laboratory fume hoods are placed that work well according to EN-14175 certification. How many radiotoxicity equivalents for inhalation (Re_{inh}) may be used in the fume hood to routinely elute a ^{99m}Tc generator ($p = -1$)?
- a) 0.2
 - b) 20
 - c) 100
 - d) 1000
- 33 The label of a package containing radioactive material indicates a transport index (TI) of 5. This means that the equivalent dose rate at 1 m from the surface of the package is approximately
- a) 5 μSv
 - b) 50 μSv
 - c) 0.5 mSv
 - d) 5 mSv

Answers to the practice multiple choice exam:

1b

2c

3c

4b

5a

6d

7d

8a

9c

10d

11c

12d

13b

14b

15a

16d

17c

18a

19c

20b

21d

22b

23a

24a

25c

26d

27d

28a

29b

30b

31c

32b

33b

