# HEALTH PHYSICS SIMPLE EXERCISES

**for radiation protection officers**

**medical applications**

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This collection of exercises is designed to give the students the opportunity to test their own skills. The assignments are simple in nature and cover the material that the student is expected to have 'understood' during the exam.

The chapter numbers in this book of simple exercises refer to the chapters in the book 'HEALTH PHYSICS for radiation protection officers - medical applications' by Frits Pleiter, Hielke Freerk Boersma and Age Froma (GARP, Groningen, 2024).

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# 1 The atom and the origin of X-radiation

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | A copper atom contains 29 protons. How many electrons are there in the electron cloud of a neutral copper atom? | *29* |
| 2 | Which particles are the building blocks of the atomic nucleus? | *protons and neutrons* |
| 3 | What is meant by excitation? | *promotion of an electron to a higher-energy level* |
| 4 | What is meant by ionization? | *removal of an electron from the electron cloud* |
| 5 | What is meant by characteristic radiation? | *radiation emitted if an electron moves from a higher-energy level to a lower-energy level, thus an electron shell closer to the atomic nucleus* |
| 6 | What is the difference between photons and electromagnetic radiation? | *there is no difference* |
| 7 | What is the energy gain of an electron that passes a potential difference of 1000 V ? | *1000 eV = 1 keV* |
| 8 | Is the binding energy in a molecule a few meV, or eV, or keV ? | *a few eV* |
| 9 | Is the energy of X-radiation a few tens of an meV, or eV, or keV ? | *a few tens of a keV* |
| 10 | Do X-rays have a harmful effect on the human body or not? | *they do* |

# 2 Logarithm

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | Consider the graph in Figure 2.1. What is the function value (vertical axis) if x = 3 (horizontal axis)? | *≈ 0.12* |
| 2 | And if x = 5 ? | *≈ 0.03* |
| 3 | If log(2) = 0.3, what is the value of log(4)? | *0.3 + 0.3 = 0.6*<br>*because log(4) = log(2 × 2)*<br>*= log(2) + log(2)* |
| 4 | What is meant by the prefix m ? | *0.001* |
| 5 | What is meant by the prefix M ? | *1000 000* |
| 6 | What is meant by the prefix μ ? | *0.000 001* |
| 7 | What is meant by the prefix k ? | *1000* |
| 8 | What is meant by the prefix n ? | *0.000 000 001* |
| 9 | What is meant by the prefix G ? | *1000 000 000* |
| 10 | How is the product 1.0 × 234.56 written with only significant digits? | $2.3 \times 10^2$ |

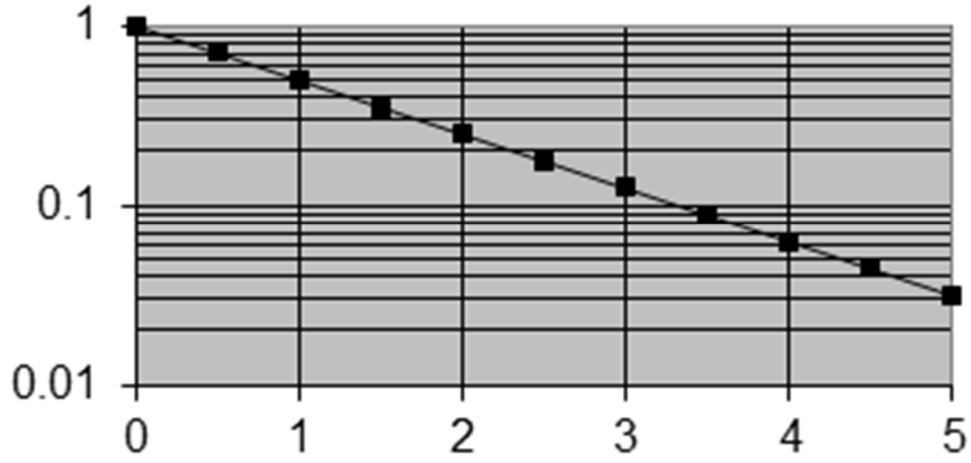


*Figure 2.1*

# 3 Interaction of ionizing radiation with matter

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | Name a few examples of electromagnetic radiation | *radio waves, radar waves, light, X-radiation, γ-radiation* |
| 2 | What is the photo-electric effect? | *ionization due to absorption of a photon* |
| 3 | What is the Compton-effect? | *scattering of a photon by an electron* |
| 4 | What is meant with scattering of radiation? | *new photons are emitted under varying angles with the initial radiation direction, and with a photon energy that is smaller than the primary energy* |
| 5 | Does scattering occur with photo-electric effect, or with Compton-effect? | *with Compton-effect* |
| 6 | Does photo-electric effect become more or less dominant with respect to Compton-effect if the photon energy increases? | *less dominant* |
| 7 | Is photo-electric effect more dominant in tissue (Z=8), or in lead (Z=82)? | *in lead* |
| 8 | Is Compton-effect more dominant in tissue (Z=8), or in lead (Z=82)? | *in tissue* |
| 9 | What is the ratio between scattered dose and entrance dose at 1 m from an irradiated area of 10 cm × 10 cm ? | *about 0.001* |
| 10 | What is the change of the scattered dose if the size of the irradiated area increases from 10 cm × 10 cm to 20 cm × 20 cm ? | *the scattered dose increases by a factor of 2 × 2 = 4, because scattering increases linearly with the size of the area* |
| 11 | What is meant with half-value thickness $d_{½}$? | *absorber thickness required to reduce the radiation intensity by a factor of 2* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 12 | What is the linear attenuation coefficient μ if the half-value thickness is 3 mm ? | $\mu = \ln(2) / d_{½} \approx 0.7 / 3\ mm$ $= 0.23\ mm^{-1} = 2.3\ cm^{-1}$ |
| 13 | What is the transmission through a layer of 5 half-value thicknesses? | $(½)^5 = 1 / 32 \approx 0.03$ |
| 14 | What is the transmission through a layer of 10 half-value thicknesses? | $(½)^{10} = (½)^5 \times (½)^5$ $\approx 0.03 \times 0.03 \approx 0.001$ |
| 15 | What is the transmission through a layer of half a half-value thickness? | $(½)^{½} = 1 / \sqrt{2} \approx 0.7$ |

# 4 Shielding of ionizing radiation

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | The half-value thickness (HVT) for shielding γ-radiation is 1 cm. How much shielding material is needed to reduce the radiation level to 3% of the initial value? | *5 HVT × 1 cm/HVT = 5 cm*<br>*transmission = (½)* $^{d/HVT}$<br>*3% = 0.03 ≈ (½)*$^5$ |
| 2 | The linear attenuation coefficient for shielding γ-straling is 1 $cm^{-1}$. How much shielding material is needed to reduce the radiation level to 3% of the initial value? | *5 × ln(2) / μ ≈ 5 × (0.7 / 1* $cm^{-1}$*)*<br>*= 3.5 cm*<br>$d_{½}$ *= ln(2) / μ*<br>*3% = 0.03 ≈ (½)*$^5$ |
| 3 | The specific mass of lead is 11.3 $g/cm^3$. What is the mass thickness of a 5 cm thick leadbrick? | *(11.3* $g/cm^3$*) × 5 cm = 57* $g/cm^2$ |
| 4 | A concrete wall has a mass thickness of 50 $g/cm^2$. The specific mass of concrete is 2.4 $g/cm^3$. How thick is the wall in cm ? | *(50* $g/cm^2$*) / (2.4* $g/cm^3$*)*<br>*= 21 cm* |
| 5 | The waiting room at the dentist must be shielded. What is the best shielding material? | *lead* |

# 5 X-ray tube

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | Does the maximum bremsstrahlung energy depend on the tube voltage or not? | *it does* |
| 2 | Does the maximum bremsstrahlung energy depend on the tube current or not? | *it does not* |
| 3 | Does the maximum bremsstrahlung energy depend on the anode material or not? | *it does not* |
| 4 | Does the energy of characteristic radiation depend on the tube voltage or not? | *it does not* |
| 5 | Does the energy of characteristic radiation depend on the tube current or not? | *it does not* |
| 6 | Does the energy of characteristic radiation depend on the anode material or not? | *it does* |
| 7 | Does the bremsstrahlung intensity depend on the tube voltage or not? | *it does* |
| 8 | Does the bremsstrahlung intensity depend on the tube current or not? | *it does* |
| 9 | Does the bremsstrahlung intensity depend on the anode material or not? | *it does* |
| 10 | Does the intensity of characteristic radiation depend on the tube voltage or not? | *it does* |
| 11 | Does the intensity of characteristic radiation depend on the tube current or not? | *it does* |
| 12 | Does the intensity of characteristic radiation depend on the anode material or not? | *it does* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 13 | Why is an X-ray device equipped with a filter? | *to reduce the skin dose of the patient* |
| 14 | Why is an X-ray device equipped with a position indicating device (PID)? | *to limit beam size and focus-skin distance* |
| 15 | Why is an X-ray device equipped with a light visor? | *to check beam size and beam position* |
| 16 | In contrast to curve (a), the curves (c) and (d) in Figure 5.1 show no intensity at low energy. Why is this? | *curve c: only internal filter*<br>*curve d: internal + extra filter* |
| 17 | What is the homogeniety of the X-ray beam? | *a measure of the width of the distribution of X-ray energies* |
| 18 | What is the hardness of the X-ray beam? | *a measure of the average X-ray energy* |
| 19 | What is meant by mAs value? | *product of tube current (in mA) and exposure time (in s)* |
| 20 | Is the radiation output of an X-ray tube greatest at 1 mA for 5 s, or 2 mA for 4 s, or 3 mA for 3 s, or 2 mA for 4 s ? | *3 mA for 3 s*<br>*(mAs value = 3 × 3 = 9 mA·s)* |

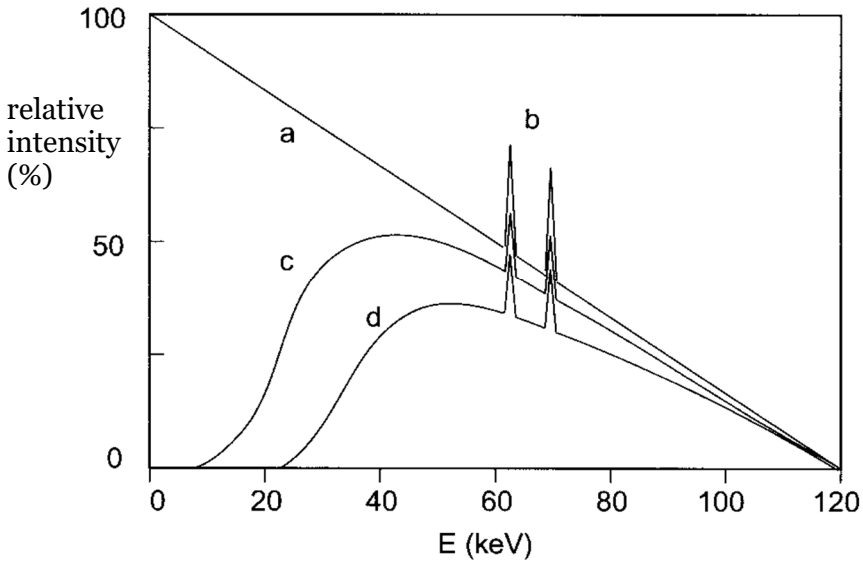


*Figure 5.1*

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 21 | What is meant by skin dose? | *the dose at the location where the X-ray beam hits the skin* |
| 22 | What is meant by entrance dose? | *the dose at the location where the X-ray beam hits the irradiated body or object* |
| 23 | What is meant by exit dose? | *the dose at the location where the X-ray beam leaves the irradiated body or object* |
| 24 | What is meant by DAP value? | *product of entrance dose and area of the irradiated surface* |
| 25 | The entrance dose is 5 mGy and the irradiated skin area size is 20 cm × 20 cm. What is the DAP value? | *DAP = 5 mGy × 20 cm × 20 cm = 2000 mGy·cm² = 2 Gy·cm²* |
| 26 | What is meant by DLP value? | *product of entrance dose and length of the irradiated body part* |
| 27 | The entrance dose is 30 mGy and the length of the irradiated body part is 30 cm. What is the DLP value? | *DLP = 30 mGy × 30 cm = 900 mGy·cm = 0.9 Gy·cm* |
| 28 | Is the DAP value used for conventional radiology, or for CT scans? | *conventional radiology* |
| 29 | Is the DLP value used for conventional radiology, or for CT scans? | *CT scans* |
| 30 | What can you tell about the scattered radiation if the DAP value or the DLP value, respectively, doubles? | *the scattered radiation doubles* |

## 6 Applications of devices

# 7 Quantities and units in radiation protection

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | What is the unit for exposure?<br>What is the symbol of this unit? | *röntgen*<br>*R* |
| 2 | What is the unit for absorbed dose?<br>What is the symbol of this unit? | *gray*<br>*Gy* |
| 3 | What is the unit for equivalent dose?<br>What is the symbol of this unit? | *sievert*<br>*Sv* |
| 4 | What is the unit for effective dose?<br>What is the symbol of this unit? | *sievert*<br>*Sv* |
| 5 | Which quantity is expressed in röntgen?<br>What is the symbol of this quantity? | *exposure*<br>*X* |
| 6 | Which quantity is expressed in gray?<br>What is the symbol of this quantity? | *absorbed dose*<br>*D* |
| 7 | Which quantity is expressed in sievert?<br>What is the symbol of this quantity? | *equivalent dose and effective dose*<br>*H and E, respectively* |
| 8 | Is the radiation weighting factor $w_R$ for X-radiation 1, or 5, or 20, or 100 ? | *1* |
| 9 | Is the radiation weighting factor $w_R$ for γ-radiation 1, or 5, or 20, or 100 ? | *1* |
| 10 | Is the risk of death determined by the absorbed dose, or the equivalent dose, or the effective dose? | *effective dose* |
| 11 | An energy of 3 joules is deposited in an organ with a mass of 30 grams. What is the absorbed dose? | *3 joule / 0.03 kg = 100 Gy* |
| 12 | What is the equivalent dose, if the absorbed dose is 1 mGy and the radiation weighting factor is $w_R = 1$? | *H = 1 × 1 = 1 mSv* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 13 | The tissue weighting factor for the thyroid is $w_{thyroid}$ = 0.04 and the equivalent dose on the thyroid is $H_{thyroid}$ = 5 Sv. What is the effective dose? | *E = 0.04 × 5 = 0.2 Sv* |
| 14 | Is 1 Sv a high or a low effective dose? | *a very high dose*<br>*it is 50 times the annual limit* |
| 15 | Is 0.1 μSv/h a high or a low equivalent dose rate? | *small equivalent dose rate*<br>*background is 1.6 mSv/y*<br>*= 1600 μSv / (365 × 24)*<br>*= 0.2 μSv/h)* |

## Orders of magnitude of the radiation dose

| | | |
|---|---|---|
| 1 | Is the average annual effective dose due to natural radiation in the Netherlands about 2 μSv, or 2 mSv, or 20 mSv ? | *2 mSv* |
| 2 | Is the average annual effective dose due to medical diagnostics in the Netherlands about 1 μSv, or 1 mSv, or 10 mSv ? | *1 mSv* |
| 3 | Is a lethal effective dose 0.1 Gy, or 1 Gy, or 100 Gy ? | *100 Gy* |
| 4 | What makes the largest contribution to natural radiation in the Nederlands? | *radon* |
| 5 | What makes the largest contribution to man-made radiation in the Nederlands? | *medical diagnostics* |

# 1. Measuring of ionizing radiation

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | Does the working of the ionisation detector depend on the counting gas or not? | *it does not* |
| 2 | Does the working of the ionisation detector depend on the gas pressure or not? | *it does not* |
| 3 | Does the working of the ionisation detector depend on the dimensions of the detector or not? | *it does not* |
| 4 | Does the working of the ionisation detector depend on the anode voltage or not? | *it does* |
| 5 | Is a Geiger-Müller counter useful as a dose monitor or not? | *it is* |
| 6 | Is a scintillation detector useful as a dose monitor or not? | *it is* |
| 7 | Which detector is (relatively) cheap: a Geiger-Müller counter, or a scintillation detector? | *Geiger-Müller counter* |
| 8 | Which unit is indicated on the scale of a dose monitor? | *gray, röntgen, or sievert* |
| 9 | Which unit is indicated on the scale of a dose-rate monitor? | *for example gray per hour* |
| 10 | Is the thermoluminescence detector (TLD) an ionisation detector, or a scintillation detector? | *scintillation detector (scintillates after heating)* |

## 2. Imaging

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | Is an underexposed X-ray photo too light or too dark? | *too light* |
| 2 | Is an overexposed X-ray photo too light or too dark? | *too dark* |
| 3 | Is the contrast of a uniform gray X-ray photo too small or too large? | *too small* |
| 4 | Is the contrast of an X-ray photo with only gray values of white and black too small or too large? | *too large* |
| 5 | What is better: a small or a large contrast? | *the contrast must be optimal to be able to answer the question* |
| 6 | The contrast of a lung image is mainly caused by the Compton-effect, or the photo-electric effect, or both effects? | *foto-electric effect* |
| 7 | The contrast of an X-ray is due to the fact that the probability of the Compton effect to occur in bone tissue is greater or smaller than in soft tissue? | *the probability is for both tissues (approximately) the same* |
| 8 | The contrast of an X-ray is due to the fact that the probability of the photo-electric effect to occur in bone tissue is greater or smaller than in soft tissue? | *greater* |
| 9 | Lung tissue gives rise to a higher or lower grey value than bone tissue? | *higher* |
| 10 | Tooth bone gives rise to a higher or lower grey value than dental pulp? | *lower* |
| 11 | The tube voltage is increased. Will the grey shade increase or decrease? | *increase because the output of the X-ray tube increases* |
| 12 | The tube voltage is decreased. Will the grey shade increase or decrease? | *decrease because the output of the X-ray tube decreases* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 13 | The mAs value is increased. Will the grey shade increase or decrease? | *increase because the output of the X-ray tube increases* |
| 14 | The mAs value is decreased. Will the grey shade increase or decrease? | *decrease because the output of the X-ray tube decreases* |
| 15 | The filter thickness is increased. Will the grey shade increase or decrease? | *decrease because the output of the X-ray tube decreases* |
| 16 | The filter thickness is reduced. Will the grey shade increase or decrease? | *increase because the output of the X-ray tube increases* |
| 17 | The tube voltage is increased. Will the contrast of the X-ray increase or decrease? | *decrease* |
| 18 | The tube voltage is decreased. Will the contrast of the X-ray increase or decrease? | *increase* |
| 19 | The mAs value is increased. Will the contrast of the X-ray increase or decrease? | *neither increase, nor decrease because the contrast remains the same* |
| 20 | The mAs value is decreased. Will the contrast of the X-ray increase or decrease? | *neither increase, nor decrease because the contrast remains the same* |
| 21 | The filter thickness is increased. Will the contrast of the X-ray increase or decrease? | *decrease* |
| 22 | The filter thickness is reduced. Will the contrast of the X-ray increase or decrease? | *increase* |
| 23 | Is a charged coupled device (CCD) a direct or an indirect imaging system? | *direct system* |
| 24 | Is a photo-stimulable phosphor (PSP) a direct or an indirect imaging system? | *direct system* |
| 25 | Is a NaI(Tl)-detector in combination with photomultiplier is a direct or an indirect imaging system? | *indirect system* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 26 | Is an aligned Bucky anti-scatter grid located at a fixed or a variable distance from the focus? | *fixed distance* |
| 27 | Is a non-aligned Bucky anti-scatter grid located at a fixed or a variable distance from the focus? | *variable distance* |
| 28 | Is the Bucky anti-scatter grid located between patient and X-ray machine, or between patient and detector? | *between patient and detector* |
| 29 | Does the Bucky anti-scatter grid lead to the greatest quality improvement for a child or for an adult? | *for an adult* |
| 30 | Does the Bucky anti-scatter grid block radiation that is scattered within or outside the patient? | *within the patient* |

# 8 Biological effects of ionizing radiation

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | Is damage produced by ionizing radiation mainly due to direct breaks of bio-molecules or to ionization of water molecules? | *ionization of water molecules* |
| 2 | Which cells are most sensitive to radiation? | *quickly dividing cells* |
| 3 | Which cells are least sensitive to radiation? | *cells that do not divide anymore* |
| 4 | Which tissue is most radiation-sensitive: bone marrow, or bone, or red blood corpuscles, or brain tissue? | *bone marrow* |
| 5 | Is there a threshhold dose for stochastic effects? | *no* |
| 6 | Is the severity of a stochastic effect dose dependend? | *no* |
| 7 | How great is the risk of death due to a stochastic effect after exposure to ionizing radiation? | *5% per sievert* |
| 8 | What is meant by: The risk factor for ionizing radiation is 0.05 per Sv? | *if 1 million people are exposed to 1 Sv, about 0.05 × 1 000 000 = 50 000 people will die* |
| 9 | Is there a threshhold dose for harmful tissue reactions? | *yes* |
| 10 | Is the severity of harmful tissue reactions dose dependend? | *yes* |
| 11 | Is leukemia a stochastic effect or a harmful tissue reaction? | *stochastic effect* |
| 12 | Is cataract a stochastic effect or a harmful tissue reaction? | *harmful tissue reaction* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 13 | What is the most likely cause of death after whole-body irradiation with a dose of 1 Gy: bone marrow syndrome, bowel syndrome, or brain syndrome? | *bone marrow syndrome* |
| 14 | What is the most likely cause of death after whole-body irradiation with a dose of 10 Gy: bone marrow syndrome, bowel syndrome, or brain syndrome? | *bowel syndrome or, at survival, bone marrow syndrom* |
| 15 | What is the most likely cause of death after whole-body irradiation with a dose of 50 Gy: bone marrow syndrome, bowel syndrome, or brain syndrome? | *brain syndrome* |
| 16 | What happens if the unborn embryo is irradiated during the first week of the pregnancy? | *either nothing or the embryo dies* |
| 17 | Is it possible that malformed organs develop if the unborn embryo is irradiated during the first week of the pregnancy? | *no* |
| 18 | Is it possible that malformed organs develop if the unborn embryo is irradiated during the second month of the pregnancy? | *yes, during this period the organs are formed* |
| 19 | Is it possible that malformed organs develop if the unborn foetus receives a dose of 1 mGy during the second half of the pregnancy? | *no, because this dose is far below the threshold dose of 100 mGy* |
| 20 | What might happen if the unborn foetus is irradiated during the second half of the pregnancy? | *growth retardation and/or lowering of IQ* |
| 21 | Is regular exposure to the dose limit of 20 mSv per year a relatively small or a relatively high occupational hazard? | *relatively (very) high occupational hazard* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 22 | The risk factor for ionizing radiation is 0.05 per Sv. The average annual dose is about 2 mSv. Nearly 18 million people live in the Netherlands. How many persons will die each year due to ionizing radiation? | *0.05 × 0.002 × 18 000 000 = 1800*<br>*(each year about 44 000 people die of cancer)* |
| 23 | When comparing the health risks of ionizing radiation and smoking, how many cigarettes correspond to an effective dose of 10 μSv: 1, 100, or 10 000? | *1 cigarette* |
| 24 | Regular smokers will smoke around 5000 cigarettes a year, putting them at an increased risk of death. Which effective dose poses a comparable risk: 0.5 mSv, 5 mSv, 50 mSv, or 500 mSv ? | *5000 × 10 μSv = 50 000 μSv = 50 mSv*<br>*because 1 sigaret corresponds to 10 μSv*<br>*(annual limit public = 1 mSv)* |
| 25 | What is wrong with the caption of the newspaper clipping shown in Figure 8.1, and why is it wrong? | *the little boy is at least 4 years old and was born long before the Chernobyl disaster; the malformations must, therefore, be caused by something else* |

# Wit-Rusland blijft lang radioactief besmet

Wit-Rusland heeft nog steeds te maken met een ernstige besmetting door het ongeluk met de kerncentrale in Tsjernobyl in 1986. En de gevolgen zullen de komende twintig jaar nauwelijks minder worden. Dat blijkt uit gegevens van Alexi Okeanog, directeur van het instituut voor medische technologie in Minsk. Hij presenteerde cijfers en kaarten over de besmetting door de gevaarlijk radioactieve stof cesium op de conferentie van de Wereldgezondheidsorganisatie (WHO) in Genève.



A victim of Chernobyl one year after the nuclear disaster.

Uit de gegevens blijkt dat de radioactieve besmetting tot 2016 nauwelijks zal afnemen. Drieëntwintig procent van Wit-Rusland zal in de visie van Okeanog een ecologisch rampgebied blijven.

Volgens Ivan Kenik, de Tsjernobyl-minister van Wit-Rusland, geeft dit land veertien procent van zijn begroting uit aan de bestrijding van de gevolgen van de Tsjernobyl-ramp. Daarbij gaat het om de bouw van nieuwe woningen, om gezondheidszorg voor duizenden mensen en om de aankoop van onbesmet voedsel. Kenik schat de kosten over de periode 1986 tot 2015 op 86 miljard dollar, zo'n 140 miljard gulden.

HERMAN DAMVELD

*Figure 8.1*

# 9 General laws and regulations

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | What must be taken into account when performing radiological work: Nuclear Energy Act, or Working Conditions Act, or both? | *both* |
| 2 | Is the Decree on Basic Safety Standards Radiation Protection a recommendation of the ICRP, or a Decree under the Nuclear Energy Act, or a Decree under the Working Conditions Act, or none of these? | *Decree under the Nuclear Energy Act* |
| 3 | Is the ICRP an independent committee of experts, or an advisory board of the Dutch government, or an advisory board of the European Community? | *an independent committee of experts* |
| 4 | What must be taken into account when performing radiological work: dose limits, or ALARA, or justification, or all of these? | *all of these* |
| 5 | What is meant by ALARA principle? | *keep the dose as low as possible (as reasonably achievable)* |
| 6 | Is the annual effective-dose limit for the general public 1 µSv, or 10 µSv, or 1 mSv, or 10 mSv ? | *1 mSv* |
| 7 | Is the annual effective-dose limit for a nonexposed worker 1 µSv, or 10 µSv, or 1 mSv, or 10 mSv ? | *1 mSv* |
| 8 | Is the annual effective-dose limit for an exposed A-worker 1 mSv, or 2 mSv, or 6 mSv, or 20 mSv.? | *20 mSv* |
| 9 | Is the annual effective-dose limit for an exposed B-worker 1 mSv, or 2 mSv, or 6 mSv, or 20 mSv ? | *6 mSv* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 10 | Is the annual dose limit for the lens of the eye of an exposed A-worker 2 mSv, or 20 mSv, or 150 mSv, or 500 mSv ? | *20 mSv* |
| 11 | Is the annual dose limit for hands, feet and skin of an exposed A-worker 2 mSv, or 20 mSv, or 150 mSv, or 500 mSv ? | *500 mSv* |
| 12 | What is the dose limit for the unborn child? | *1 mSv (from the moment the pregnancy has been reported to the employer)* |
| 13 | Must an area in which the annual effective dose can exceed 6 mSv, be qualified as controlled area ("gecontroleerde zone") or as supervised area ("bewaakte zone")? | *controlled area* |
| 14 | Which is the largest annual dose that can possibly be received in a supervised area ("bewaakte zone")? | *6 mSv* |
| 15 | Is it allowed for a nonexposed worker to work inside a supervised area ("bewaakte zone")? | *yes, provided he can not receive more than 1 mSv per year* |
| 16 | The radiation protection officer must ensure that the annual effective dose on the public road does not exceed a certain value. What is that value in the case of an application that requires a permit? | *0.1 mSv = 100 μSv* |
| 17 | The radiation protection officer must ensure that the annual effective dose on the public road does not exceed a certain value. What is that value in the case of an application that requires registration? | *0.01 mSv = 10 μSv* |
| 18 | In radiation protection, how many hours are you assumed to work per day? | *8* |
| 19 | In radiation protection, how many hours are you assumed to work per week? | *40* |

| | QUESTIONS | *ANSWERS* |
|---|---|---|
| 20 | In radiation protection, how many hours are you assumed to work per year? | *2000* |

## 3. Specific regulations for devices

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | Is an intra-oral X-ray device used inside the dental practice subject to licensing or not? | *no* |
| 2 | Is a cone-beam CT-scanner subject to licensing or not? | *yes* |
| 3 | Is an X-ray device used at various locations subject to licensing or not? | *yes* |
| 4 | How often should an X-ray device be checked for proper operation? | *at least once a year* |
| 5 | Must a radiation protection officer be appointed for an X-ray device that is subject to registration? | *yes* |
| 6 | Why must an X-ray device for medical diagnostics be equipped with a filter? | *to remove low-energy photons from the beam* |
| 7 | Why must an X-ray device for medical diagnostics be equipped with a position indicating device (PID)? | *to limit the beam size and skin-focus distance* |
| 8 | Why must an X-ray device for medical diagnostics be equipped with a light visor (diaphragm)? | *to check size and position of the beam* |
| 9 | Is a written protocal for any medical application of X-rays required or not? | *it is* |
| 10 | Should always be asked for a potential pregnancy before a radiological X-ray examination of a female patient is performed? | *no, only if it is relevant* |

**10 Specific regulations for medical professionals / relationship with the BIG act**

# 11 Practical radiation protection for devices

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | Is it or is it not the task of the radiation protection officer to introduce new employees into house rules and protocols? | *it is* |
| 2 | Is it or is it not the task of the radiation protection officer to supervise the use of adequate personal protection? | *it is* |
| 3 | Who is in charge of the nuclear energy act file? | *radiation protection officer* |
| 4 | Is the radiation protection officer allowed to have the nuclear energy act file managed by the secretariat? | *no* |
| 5 | May the radiation protection officer carry out a risk analysis or not? | *he may* |
| 6 | May the radiation protection officer approve a risk analysis or not? | *he may not* |
| 7 | What is an inherently safe device? | *device for which the equivalent dose rate at 10 cm from any accessible part of the outside does not exceed 1 µSv/h* |
| 8 | The source-oriented strategy dictates that personal protective equipment is used, the tube output is reduced and the distance is increased. What is the first step to take? | *reduce the tube output* |
| 9 | The source-oriented strategy dictates that personal protective equipment is used, the tube output is reduced and the distance is increased. What is the last step to take? | *use personal protective equipment* |
| 10 | The distance to the focus is doubled. What happens to the entrance dose? | *entrance dose four times lower (inverse square law)* |

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 11 | For a medical procedure, one often uses a diagnostic reference level (DRL). What is the DRL intended for? | *to apply ALARA* |
| 12 | Why is the cross-section of the X-ray beam reduced when taking an X-ray photo | *to reduce direct radiation for the patient and scatter radiation for bystanders* |
| 13 | In which way is the ALARA principle applied in a radiological examination? | *by collimating the beam, applying a filter, and reducing the mAs value* |
| 14 | Which relatively radiation-sensitive organ is sometimes NOT shielded when wearing a all-side lead apron? | *thyroid* |



*portable X-ray device*

| | | |
|---|---|---|
| 15 | There are nonmobile and portable diagnostic X-ray devices? Which of these devices generally gives a higher dose for the operator, or does it not matter? | *portable devices give higher dose*<br>*because operator can not take distance* |

# 12 Risk analysis for the radiology department

| | *QUESTIONS* | *ANSWERS* |
|---|---|---|
| 1 | A mobile X-ray device is moved closer to the patient. Will the entrance dose increase or decrease? | *increase* |
| 2 | A mobile X-ray device is moved closer to the patient. Will the scattered radiation increase or decrease? | *increase* |
| 3 | The setting of light visor is changed from 30 cm × 30 cm to 25 cm × 25 cm. Will the entrance dose increase or decrease? | *remains the same* |
| 4 | The setting of light visor is changed from 30 cm × 30 cm to 25 cm × 25 cm. Will the scattered radiation increase or decrease? | *decrease* |
| 5 | Which is the best choice to reduce the received dose: to work twice as fast or to double the distance? | *double the distance (inverse square law)* |
| 6 | Which is the best choice to reduce the received dose: to work four times as fast or to double the distance? | *double the distance (more haste less speed)* |
| 7 | Does the dose decrease when the work is done faster? | *yes* |
| 8 | Does the dose rate decrease when the work is done faster? | *no* |
| 9 | Does the dose decrease when the working distance is increased? | *yes* |
| 10 | Does the dose rate decrease when the working distance is increased? | *yes* |