Radiation Protection Officer

medical applications

Simple Exercises

September 25, 2020

university of groningen / health, safety and sustainability / garp

CONTENTS

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*
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	The binding energy in a molecule is a few meV, or eV, or keV?	*a few eV*
9	The energy of X-radiation is is a few tens of an meV, or eV, or keV?	*a few tens of a keV*
10	X-rays do or do not have a harmful effect on the human body?	*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 (because 4 = 2 × 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?	*2.3×10^2*

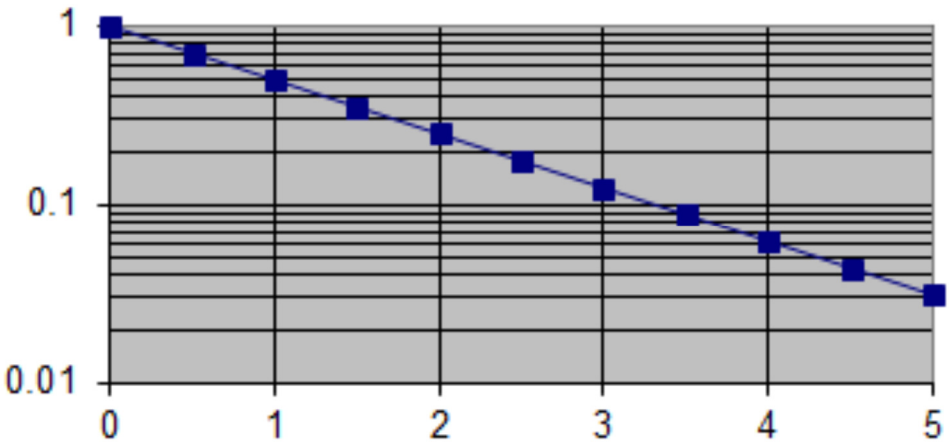


Figure 2.1

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*
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 ?	*0.7 / 3 = 0.23 mm^{-1} = 2.3 cm^{-1}*
13	What is the transmission through a layer of 5 half-value thicknesses?	*$1 / 2^5 = 1 / 32 \approx 0.03$*
14	What is the transmission through a layer of 10 half-value thicknesses?	*$1 / 2^{10} \approx 0.03 \times 0.03 \approx 0.001$*
15	What is the transmission through a layer of half a half-value thickness?	*$1 / \sqrt{2}$*

4 Shielding of ionizing radiation

	QUESTIONS	*ANSWERS*
1	The half-value thickness 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 × 1 = 5 cm* *(3% ≈ 1/2⁵)*
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 × (0.7 / 1) = 3.5 cm* *(3% ≈ 1/2⁵ and $d_{½} = 0.7/\mu$)*
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 = 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	The maximum bremsstrahlung energy does or does not depend on the tube voltage?	*it does*
2	The maximum bremsstrahlung energy does or does not depend on the tube current?	*it does not*
3	The maximum bremsstrahlung energy does or does not depend on the anode material?	*it does not*
4	The energy of characteristic radiation does or does not depend on the tube voltage?	*it does not*
5	The energy of characteristic radiation does or does not depend on the tube current?	*it does not*
6	The energy of characteristic radiation does or does not depend on the anode material?	*it does*
7	The bremsstrahlung intensity does or does not depend on the tube voltage?	*it does*
8	The bremsstrahlung intensity does or does not depend on the tube current?	*it does*
9	The bremsstrahlung intensity does or does not depend on the anode material?	*it does*
10	The intensity of characteristic radiation does or does not depend on the tube voltage?	*it does*
11	The intensity of characteristic radiation does or does not depend on the tube current?	*it does*
12	The intensity of characteristic radiation does or does not depend on the anode material?	*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 skin-focus 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?	*this is due to the 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	The radiation output of an X-ray tube is 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* *(mAs value = 3 × 3 = 9 mAs)*

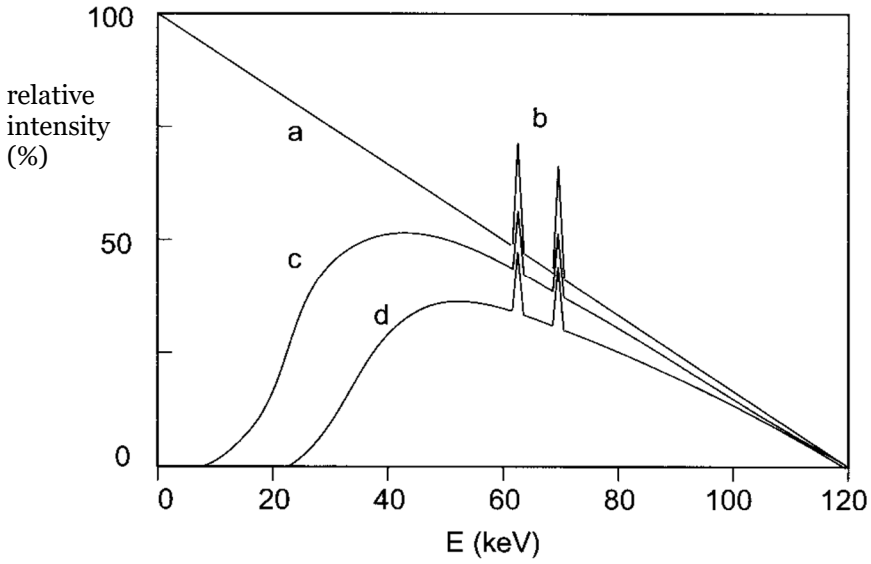


Figure 5.1

	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 beam-spot size is 20 cm × 20 cm. What is the DAP value?	*DAP = 5 × 20 × 20 = 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 × 30 = 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? What is the symbol of this unit?	*röntgen* *R*
2	What is the unit for absorbed dose? What is the symbol of this unit?	*gray* *Gy*
3	What is the unit for equivalent dose? What is the symbol of this unit?	*sievert* *Sv*
4	What is the unit for effective dose? What is the symbol of this unit?	*sievert* *Sv*
5	Which quantity is expressed in röntgen? What is the symbol of this quantity?	*exposure* *X*
6	Which quantity is expressed in gray? What is the symbol of this quantity?	*absorbed dose* *D*
7	Which quantity is expressed in sievert? What is the symbol of this quantity?	*equivalent dose and effective dose* *H and E, respectively*
8	The radiation weighting factor w_R for X-radiation is 1, or 5, or 20, or 100 ?	*1*
9	The radiation weighting factor w_R for γ-radiation is 1, or 5, or 20, or 100 ?	*1*
10	The risk of death is 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 $w_R = 1$?	*$H = 1 \times 1 = 1$ 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 large or a small effective dose?	*a very large dose (50 times the annual limit)*
15	Is 0.1 µSv/h a large or a small equivalent dose rate?	*small equivalent dose rate (background is 1.6 mSv/y = 1600 µSv / (365 × 24) = 0.2 µSv/h)*

Orders of magnitude of the radiation dose

1	The average annual effective dose due to natural radiation in the Netherlands is about 2 µSv, or 2 mSv, or 20 mSv ?	*2 mSv*
2	The average annual effective dose due to medical diagnostics in the Netherlands is about 1 µSv, or 1 mSv, or 10 mSv ?	*1 mSv*
3	A lethal dose is 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*

8 Measuring of ionizing radiation

	QUESTIONS	*ANSWERS*
1	The working of the ionisation detector does or does not depend on the counting gas?	*it does not*
2	The working of the ionisation detector does or does not depend on the gas pressure?	*it does not*
3	The working of the ionisation detector does or does not depend on the dimensions of the detector?	*it does not*
4	The working of the ionisation detector does or does not depend on the anode voltage?	*it does*
5	A Geiger-Müller counter is or is not useful as a dose monitor?	*it is*
6	A scintillation detector is or is not useful as a dose monitor?	*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* *(or 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)*

9 Imaging

	QUESTIONS	*ANSWERS*
1	An underexposed X-ray photo is too light, or too dark?	*too light*
2	An overexposed X-ray photo is too light, or too dark?	*too dark*
3	The contrast of a uniform gray X-ray photo is too small, or too large?	*too small*
4	The contrast of an X-ray photo with only gray values of white and black is 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 larger or smaller grey value than bone tissue?	*larger*
10	Tooth bone gives rise to a larger or a smaller grey value than dental pulp?	*larger*
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 photo increase or decrease?	*decrease*
18	The tube voltage is decreased. Will the contrast of the X-ray photo increase or decrease?	*increase*
19	The mAs value is increased. Will the contrast of the X-ray photo increase or decrease?	*remains the same*
20	The mAs value is decreased. Will the contrast of the X-ray photo increase or decrease?	*remains the same*
21	The filter thickness is increased. Will the contrast of the X-ray photo increase or decrease?	*decrease*
22	The filter thickness is reduced. Will the contrast of the X-ray photo increase or decrease?	*increase*
23	A charged coupled device (CCD) is a direct or an indirect imaging system?	*direct system*
24	A photo-stimulable phosphor (PSP) is a direct or an indirect imaging system?	*direct system*
25	A NaI(Tl)-detector in combination with a photomultiplier is a direct or an indirect imaging system?	*indirect system*

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

10 Biological effects of ionizing radiation

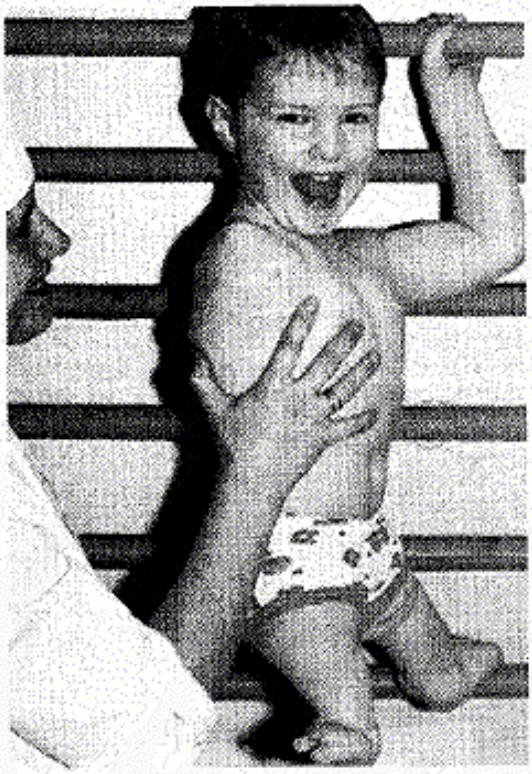
	QUESTIONS	*ANSWERS*
1	Damage produced by ionizing radiation is mainly due to direct breaks of bio-molecules or to ionization of water molecules?	*ionization of water molecules*
2	Which cells are most sensitive to radiation?	*quickly dividing cells*
3	Which cells are least sensitive to radiation?	*cells that do not divide anymore*
4	The most radiation-sensitive tissue is 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	Leukemia is a stochastic effect, or a harmful tissue reaction?	*stochastic effect*
12	Cataract is a stochastic effect, or a harmful tissue reaction?	*harmful tissue reaction*

	QUESTIONS	*ANSWERS*
13	After a total-body irradiation to a dose of 1 Gy, people will proably die because of fatal damage to the bone marrow, or to the gastro-intestinal tract, or to the nervous system?	*bone marrow*
14	After a total-body irradiation to a dose of 10 Gy, people will proably die because of fatal damage to the bone marrow, or to the gastro-intestinal tract, or to the nervous system?	*gastro-intestinal tract or, at survival, bone marrow*
15	After a total-body irradiation to a dose of more than 50 Gy, people will die because of damage to the bone marrow, or to the gastro-intestinal tract, or to the nervous system?	*nervous system*
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 is irradiated during the second half of the pregnancy?	*no, organ formation is by then completed*
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	Regular exposure to the dose limit of 20 mSv per year is 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 17 million people live in the Netherlands. How many persons will die each year due to ionizing radiation?	*0.05 × 0.002 × 17 000 000 = 1700* *(each year about 44 000 people die of cancer)*
23	The health risk of an effective dose of 10 μSv corresponds with the risk from smoking 1, or 100, or 10 000 cigarettes?	*1 cigarette*
24	A regular smoker will smoke around 5000 cigarettes a year. The risk of death for this smoker is comparable to the radiation risk of 0.5 mSv, or 5 mSv, or 50 mSv, or 500 mSv?	*5000 × 10 μSv = 50 000 μSv = 50 mSv* *(annual limit for the general public = 1 mSv)*
25	What is wrong with the caption of the newspaper clipping shown in Figure 10.1, 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 10.1

11 General laws and regulations

	QUESTIONS	*ANSWERS*
1	Radiological workers must comply with the Nuclear Energy Act, or with the Working Conditions Act, or with both?	*with both*
2	The Decree on Basic Safety Stanndards Radiation Protection is 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	The ICRP is 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	Radiological workers must comply with the dose limits, or with the ALARA principle, or with the principle of justification, or with all these principles?	*with all principles*
5	What is meant by ALARA principle?	*keep the dose as low as possible (as reasonably achievable)*
6	The annual effective-dose limit for the general public is 1 μSv, or 10 μSv, or 1 mSv, or 10 mSv ?	*1 mSv*
7	The annual effective-dose limit for a nonexposed worker is 1 μSv, or 10 μSv, or 1 mSv, or 10 mSv ?	*1 mSv*
8	The annual effective-dose limit for an exposed A-worker is 1 mSv, or 2 mSv, or 6 mSv, or 20 mSv.?	*20 mSv*
9	The annual effective-dose limit for an exposed B-worker is 1 mSv, or 2 mSv, or 6 mSv, or 20 mSv ?	*6 mSv*

	QUESTIONS	*ANSWERS*
10	The annual dose limit for the lens of the eye of an exposed A-worker is 2 mSv, or 20 mSv, or 150 mSv, or 500 mSv ?	*20 mSv*
11	The annual dose limit for hands, feet and skin of an exposed A-worker is 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	An area in which the annual effective dose can exceed 6 mSv, must 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*

12 Specific regulations for devices

	QUESTIONS	*ANSWERS*
1	Is an intra-oral X-ray device used inside the dental practice subject to licensing?	*no*
2	Is a cone-beam CT-scanner in the dental practice subject to licensing?	*yes*
3	Is an X-ray device used at various locations subject to licensing?	*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	A written protocal for any medical application of X-rays is or is not required?	*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*

13 Specific regulations for medical professionals / relationship with the BIG act

14 Practical radiation protection for devices

	QUESTIONS	*ANSWERS*
1	It is or is not the task of the radiation protection officer to introduce new employees into house rules and protocols?	*it is*
2	It is or is 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	The radiation protection officer may or may not carry out a risk analysis?	*he may*
6	The radiation protection officer may or may not approve a risk analysis?	*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 DRN 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 (operator can not take distance)*

15 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	The best choice to reduce the received dose is to work twice as fast, or to double the distance?	*double the distance (inverse square law)*
6	The best choice to reduce the received dose is 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*