

## Final exam questions ED 2017-2018

1. Radiation
  - a) Properties and types of radiation
  - b) Physical parameters of radiation
2. Law of attenuation of radiation
  - a) Experimental interpretation of the law
  - b) Forms and validity of the law
  - c) Application of the law in medical and laboratory practice
3. Basic principles of optics I
  - a) refraction of light; Fermat's principle; Snellius-Descartes law
  - b) applications: prism, optical fiber
4. Basic principles of optics II
  - a) Reflection, spectral reflectance
  - b) Scattering : Rayleigh-, Mie-, Raman-scattering
5. Optics of the human eye
  - a) Image formation and power of the eye
  - b) Visual acuity, resolution of the eye; accommodation power, eyeglasses
6. Image formation by optical devices and their medical application
  - a) Optical lenses, lens systems, microscope
  - b) Resolution; Abbe's principle
7. Light as electromagnetic wave
  - a) Parameters of electromagnetic waves
  - b) Family of electromagnetic radiation; electromagnetic spectrum
8. Wave nature of light
  - a) Superposition, interference
  - b) diffraction, optical grating, dispersion of white light
9. Corpuscular nature of light
  - a) photoelectric effect (experiment and its interpretation); the photon concept
  - b) application of photoelectric phenomenon
10. Absorption of light
  - a) Mechanism of light absorption; the absorption spectrum
  - b) Lambert-Beer's law and its medical application
  - c) Measuring techniques: light sources, monochromators, detectors
11. Blackbody radiation
  - a) absorption coefficient; radiant emittance; Kirchhoff's law
  - b) origin of blackbody radiation
  - c) Spectrum of blackbody radiation; Wien's displacement law
12. Basic principles of telethermography
  - a) Stefan-Boltzmann law
  - b) Thermal radiation of human body
  - c) Other application fields of thermal radiation
13. Luminescence
  - a) Mechanisms of luminescence; Kasha's rule
  - b) Emission spectrum, Stokes shift
  - c) Life time of fluorescence and phosphorescence
14. Application fields of luminescence

- a) Light sources based on luminescence
- b) Medical and laboratory use of luminescence
- 15. Concept of light amplification
  - a) Optical pumping and population inversion
  - b) Induced emission
- 16. Production of LASER light
  - a) Preconditions for LASER operation
  - b) Emission and properties of LASER light
- 17. Medical application of LASERs
  - a) Characteristics of LASER light
  - b) Biological effects and medical application of LASER light
- 18. Generation of X-ray I.
  - a) Structure and operation of X-ray tube
  - b) Generation and spectrum of Bremsstrahlung
- 19. Generation of X-ray II.
  - a) Power and efficiency of the X-ray tube
  - b) Generation and spectrum of characteristic radiation
- 20. Absorption of X-ray
  - a) Attenuation and mass attenuation coefficient
  - b) Mechanisms of the absorption
- 21. Medical application of X-ray absorption
  - a) Factors influencing X-ray absorption
  - b) Basic principles of X-ray diagnostics and radiation protection
  - c) Application of contrast materials
- 22. X-ray diagnostics I
  - a) Summation image; fluoroscopy
  - b) X-ray image amplifier; DSA
- 23. X-ray diagnostics II
  - a) Concept of CT; Hounsfield units, spiral CT, spatial and temporal resolution
  - b) Generations of CT
- 24. Nuclear radiation
  - a) Composition and stability of the nucleus
  - b) Nuclear forces; mass defect
- 25. Radioactive decay law
  - a) Activity; definition and factors influencing its value
  - b) Change of activity in time; decay constant, half life
- 26.  $\alpha$ - and  $\beta$ -radiation
  - a)  $\alpha$ -particle; spectrum of  $\alpha$ -radiation; interaction with matter
  - b) Types, characteristics and spectrum of  $\beta$ -radiation; interaction with matter; annihilation
- 27. Gamma-radiation and its interaction with matter
  - a) Nature, characteristics and spectrum of gamma-radiation; isomeric transition
  - b) Interaction of Gamma-radiation with matter
- 28. Basic principles of diagnostic application of radioisotopes
  - a) Basic principles and information provided by isotope diagnostics
  - b) Selection rules for in vivo application of radioisotopes

29. Methods in isotope diagnostics I.
  - a) Isotope accumulation curve; effective and biological half life
  - b) Gamma camera (structure and operation); static and dynamic pictures
30. Methods in isotope diagnostics II.
  - a) SPECT
  - b) PET
31. Radiotherapy
  - a) Types of radiation in radiotherapy and their absorption characteristics
  - b) Relative depth-dose
32. Accelerators and therapeutic devices
  - a) Linear accelerator and cyclotron
  - b) Collimators
  - c) Gamma knives, brachytherapy
33. Dosimetry of ionizing radiation
  - a) Absorbed dose (definition, unit, validity)
  - b) Exposure, (definition, unit, validity);
  - c) Measurement of exposure
34. Detection of ionizing radiation
  - a) Devices based ion gas ionization
  - b) Scintillation counter, thermoluminescent dosimeter
35. Ionizing radiation caused damages
  - a) Characteristics of stochastic and deterministic damages; examples
  - b) Radiophysics and radiochemistry of stochastic and deterministic damages.
36. Quantitative characterization of biological effects of ionizing radiation
  - a) Equivalent dose effective dose; weighting factors;
  - b) Origin and biological significance of background radiation
37. Natural and artificial sources of ionizing radiation
  - a) Medical sources of ionizing radiation and natural background radiation
  - b) ALARA principle
  - b) PET
38. Basic principles of medical application of ultrasound
  - a) Sound and ultrasound as mechanical waves; their parameters
  - b) Propagation, absorption and reflection of US; acoustic impedance
39. Generation and detection of ultrasound
  - a) Generation and detection of US
  - b) US techniques, echo principle
40. Ultrasound imaging
  - a) US image and its interpretation
  - b) A-, B- and (T)M images
41. Doppler method; US therapy
  - a) Doppler effect and its medical application
  - b) Biological effects of US; US therapy
  - c) Shock wave therapy
42. Basic principles of electricity
  - a) Elements of electric circuits; properties and parameters
  - b) Electric behavior of biological structures
43. Detection and analysis of electric signals

- a) Classification of signals
- a) Electric amplifiers, types and parameters
- b) Fourier's principle
- 44. Interpretation of images made by various diagnostic methods
  - a) image, pixel, voxel
  - b) Interpretation and comparison of information held by various diagnostic images
- 45. Medical imaging methods
  - a) Direct and computed tomographic methods
  - b) Non-tomographic images - types and interpretation
- 46. Volume transport
  - a) General characteristics of volume transport
  - b) Comparison of the flow of ideal and real fluids
- 47. Flow of fluids and gases; methods for measuring the volumetric flow rate
  - a) Law of continuity and the blood flow
  - b) Bernoulli's law for ideal fluids (an example of its consequences for the blood flow)
- 48. Flow of real fluids
  - a) Newton's law of friction (explanation and validity); its application for spherical particle
  - b) Comparison of laminar and turbulent flow; critical velocity;
- 49. Description and modeling of blood flow
  - a) Fluid flow in a tube; Hagen-Poiseuille's law (explanation and validity)
  - b) Application of Hagen-Poiseuille law to blood-circulation; comparison of Hagen-Poiseuille's law and Ohm's law
- 50. Characteristics of molecular motion
  - a) Qualitative description of molecular motion; thermal motion, Brownian motion, drift speed, mobility
  - b) Visualization and quantitative characterization of molecular motion; mean free path, mobility
- 51. Diffusion
  - a) Fick's first law; diffusion coefficient
  - b) Generalized continuity-equation; Fick's second law and its meaning
- 52. Osmosis; osmotic phenomenon
  - a) Explanation of the osmotic pressure; van't Hoff law
  - b) Problems of osmotic pressure in practice; isotonic solutions
- 53. Thermodynamic aspects of transport processes
  - a) Thermodiffusion; heat conduction
  - b) Extensive and intensive quantities; uniform description of transport processes; Onsager-relation
- 54. Transport through cell membrane; chemical and electro-chemical potential
  - a) Classification and characterization of transport processes
  - b) Membrane permeability constant; diffusion of molecules; electrodiffusion
- 55. Interpretation of resting membrane potential
  - a) Equilibrium model and electro-diffusion (transport) model
  - b) Equivalent circuit model of cell membrane
- 56. Alteration of resting membrane potential I.
  - a) Local changes of membrane potential

- c) Time constant and space constant of the cell membrane
- 57. Alteration of resting membrane potential II.
  - a) Action potential; ion transport during action potential
  - b) Depolarization threshold and its changes during action potential
- 58. Propagation of action potential
  - a) Speed of signal propagation
  - b) Synaptic signal transmission; spatial and temporal summation
- 59. Basic principles of sensory function I.
  - a) Types of stimuli and modalities
  - b) Types of receptors
  - c) Psycho-physical laws
- 60. Basic principles of sensory function II.
  - a) receptor potential; Its parameters and role in signal transition
  - b) Connection between stimulus intensity and parameters of receptor potential and action potential
- 61. Physical principles of functioning of sensory organs
  - a) Biophysical basics of vision
  - b) Biophysical basics of hearing
- 62. Medical applications of electric pulses I.
  - a) High frequency heat therapy
  - b) Galvan therapy; iontophoresis
- 63. Medical applications of electric pulses II.
  - a) Stimulus characteristic curves
  - b) Parameters of electric stimuli, pacemaker
- 64. Basic principles of ECG
  - a) Heart muscle as source of electric signal
  - b) Integral vector
  - c) Electrodes and lead systems in ECG
- 65. Modern microscopic techniques
  - a) confocal laser-microscopy
  - b) two-photon excitation
- 66. Scanning techniques in modern microscopy
  - a) Concept of scanning
  - b) Atomic force microscope
- 67. Concept of electron microscopy
  - a) resolution of electron microscope
  - b) TEM, SEM
- 68. Biostatistics I
  - a) Variable and probability distribution
  - b) Normal distribution and its parameters
- 69. Biostatistics II
  - a) Sample and statistical characteristics
  - b) Estimation of the expected value
- 70. Biostatistics III
  - a) linear regression
  - b) correlation
- 71. Hypothesis testing I

a) t-distribution; null-hypothesis;

b) correlation t-test

72. Hypothesis testing II

a) t-test for one sample. T-test for two samples

$\chi^2$ -test