

## **Theoretical questions for the final exam ED 2012.**

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 light
  - a) Light as "the most important" radiation
  - b) Fermat's principle and rules of geometrical optics
4. Optics of the human eye
  - a) Image formation and power of the eye
  - b) Visual acuity, resolution of the eye; accommodation power, eyeglasses
5. Image formation by optical devices and their medical application
  - a) Optical fibers and their application in the endoscopy
  - b) Lenses, lens systems, microscopes
6. Light as electromagnetic wave
  - a) Parameters of electromagnetic waves
  - b) Interference, diffraction (experiments and interpretation)
  - c) Family of electromagnetic radiation; electromagnetic spectrum
7. Corpuscular nature of light
  - a) photoelectric effect (experiment and its interpretation); the photon concept
  - b) particles and wave nature of particles
8. 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
9. Nature of absolute blackbody  
absorption coefficient; radiant emittance; Kirchhoff's law
10. Blackbody (thermal) radiation
  - a) Source and nature of blackbody radiation
  - b) Spectrum of blackbody radiation; Wiens's displacement law
11. Basic principles of telethermography
  - a) Stefan-Boltzmann law
  - b) Thermal radiation of human body
  - c) Other application fields of thermal radiation
12. Luminescence
  - a) Mechanisms of luminescence; Kasha's rule
  - b) Emission spectrum, Stokes rule
  - c) Life time of fluorescence and phosphorescence
13. Application fields of luminescence
  - a) Light sources based on luminescence
  - b) Medical and laboratory use of luminescence
14. Concept of light amplification
  - a) Optical pumping and population inversion
  - b) Induced emission
15. Light microscopes
  - a) Resolving power

- b) Abbe's principle
- 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
  - c) Factors influencing the parameters of spectrum
- 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. Biostatistics I
  - a) Variable and probability distribution
  - b) Normal distribution and its parameters
- 25. Biostatistics II
  - a) Sample and statistical characteristics
  - b) Estimation of the expected value
- 26. Basic principles of ECG
  - a) Heart muscle as source of electric signal
  - b) integral vector
  - c) Electrodes and lead systems in ECG
- 27. Nuclear radiation
  - a) Composition and stability of the nucleus
  - b) Nuclear forces; mass defect
- 28. Radioactive decay law
  - a) Activity; definition and factors influencing its value
  - b) Change of activity in time; decay constant, half life
- 29.  $\alpha$ - 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
- 30. Gamma-radiation and its interaction with matter
  - a) Nature, characteristics and spectrum of gamma-radiation; izomeric transition
  - b) Interaction of Gamma-radiation with matter

31. 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
32. Methods in isotope diagnostics I.
  - a) Isotope accumulation curve; effective and biological half life
  - b) Gamma camera (structure and operation); static and dynamic pictures
33. Radiotherapy
  - a) Types of radiation in radiotherapy and their absorption characteristics
  - b) Relative depth-dose
34. Accelerators and therapeutic devices
  - a) Linear accelerator and cyclotron
  - b) Collimators
  - c) Gamma knives, brachytherapy
35. Detection of ionizing radiation
  - a) Devices based ion gas ionization
  - b) Scintillation counter
36. Ionizing radiation caused damages
  - a) Characteristics of stochastic and deterministic damages; examples
  - b) Radiophysics and radiochemistry of stochastic and deterministic damages.
37. Dosimetry of ionizing radiation
  - a) Absorbed dose (definition, unit, validity)
  - b) Exposure, (definition, unit, validity);
  - c) Measurement of exposure
38. Quantitative characterization of biological effects of ionizing radiation
  - a) Equivalent dose effective dose; weighting factors;
  - b) Origin and biological significance of background radiation
39. Natural and artificial sources of ionizing radiation
  - a) Medical sources of ionizing radiation and natural background radiation
  - b) ALARA principle
40. Isotope diagnostics II
  - a) SPECT
  - b) PET
41. Physical principles of functioning of sensory organs
  - a) Biophysical basics of vision
  - b) Biophysical basics of hearing
42. Detection of ionizing radiation II
  - a) Thermoluminescent dosimeter
  - b) Filmdosimeter
43. Biostatistics III
  - a) Linear regression
  - b) Correlation
44. 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
45. Generation and detection of ultrasound
  - a) Generation and detection of US
  - b) US techniques, echo principle
46. Ultrasound imaging
  - a) US image and its interpretation
  - b) A-, B- and (T)M images

47. Doppler method; US therapy
  - a) Doppler effect and its medical application
  - b) Biological effects of US; US therapy
  - c) Shock wave therapy
48. Biophysics of sensory function
  - a) Types of stimuli and modalities
  - b) Types of receptors
  - c) psycho-physical laws
49. Interpretation of images made by various diagnostic methods
  - a) image, pixel, voxel
  - b) Interpretation and comparison of information held by various diagnostic images
50. Medical imaging methods
  - a) Direct and computed tomographic methods
  - b) Non-tomographic images - types and interpretation
51. Volume transport
  - a) General characteristics of volume transport
  - b) Comparison of the flow of ideal and real fluids
52. 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)
53. 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;
54. 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
55. 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, drift speed, mobility
56. Diffusion
  - a) Fick's first law; diffusion coefficient
  - b) Generalized continuity-equation; Fick's second law and its meaning
57. Diffusion as a consequence of molecular motion
  - a) Random-walk problem and its solution
  - b) Comparison of the results based on the Fick's laws
58. Osmosis; osmotic phenomenon
  - a) Explanation of the osmotic pressure; van't Hoff law
  - b) Problems of osmotic pressure in practice; isotonic solutions
59. Thermodynamic aspects of transport processes
  - a) Thermodiffusion; heat conduction
  - b) Extensive and intensive quantities; uniform description of transport processes; Onsager-relation
60. Transport across the cell membrane; chemical and electro-chemical potential
  - a) Classification and characterization of transport processes
  - b) Membrane permeability constant; diffusion of molecules; electrodiffusion
61. Interpretation of resting membrane potential

- a) Equilibrium model and electrodiffusion (transport) model
- b) Equivalent circuit model of cell membrane
- 62. Alteration of resting membrane potential I.
  - a) Local changes of membrane potential
  - c) Time constant and space constant of the cell membrane
- 63. Alteration of resting membrane potential II.
  - a) Action potential; ion transport during action potential
  - b) Depolarization threshold and its changes during action potential
- 64 Propagation of action potential
  - a) Speed of signal propagation
  - b) Synaptic signal transmission; spatial and temporal summation
- 65. 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
- 66. Medical signal processing 1.
  - a) Classification and information content of the signals
  - b) Signal processing; signal to noise ratio
- 67. Medical signal processing 2.
  - a) Amplifiers and their characteristics
  - b) Fourier theorem
- 68. Electric phenomena
  - a) Electric field, electric potential
  - b) Direct and alternating current
  - b) Conductors and capacitors and their parameters; RC circuits