Medical biophysics theoretical questions 2012

1. 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

2. .Image formation by optical devices and their medical application
- a) Optical fibers and their application in the endoscopy
- b) Lenses, lens systems, microscopes

3. Light as electromagnetic wave
- a) Parameters of electromagnetic waves
- b) Interference, diffraction , polarization
- c) Family of electromagnetic radiation; electromagnetic spectrum

4. Corpuscular nature of light
- a) photoelectric effect (experiment and its interpretation); the photon concept
- b) particles and wave nature of particles (matter wave)

5. Thermal radiation
- absorption coefficient; radiant emittance; Kirchhoff's law
- b) Spectrum of blackbody radiation; Wiens's displacement law

6. Basic principles of telethermography
- a) Stefan-Boltzmann law
- b) Thermal radiation of human body

7. Luminescence
- a) Mechanisms of luminescence; fluorescence, phosphorescence, Kasha's rule
- b) Emission spectrum, Stokes rule
- c) Light sources based on luminescence

8. Fluorescence - characteristic parameters
- a) emission spectrum, quantum yield, lifetime, anisotropy
- b) fluorescent probes, fluorescence microscopic techniques, confocal microscopy

9. Production of LASER light
- a) Preconditions for LASER operation
- b) Emission and properties of LASER light

10. Medical application of LASERs
- a) Surgical application of LASERs, types of applied LASERs, viewpoints for selection
- b) Ophthalmological application of LASERs, fields of application, viewpoints for selection

11. 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

12. Generation of X-ray II.
- a) Power and efficiency of the X-ray tube
- b) Effect of accelerating voltage and anode current on the quality and quantity of radiation
- c) Generation and spectrum of characteristic radiation

13. Absorption of X-ray
- a) Attenuation and mass attenuation coefficient
- b) Mechanisms of the absorption

14. 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

15. X-ray diagnostics I
- a) Summation image; fluoroscopy
- b) X-ray image amplifier; DSA

16. X-ray diagnostics II
- a) Concept of CT; Hounsfield units, spiral CT, spatial and temporal resolution
- b) Generations of CT

17. Nuclear radiation
- a) Activity; definition and factors influencing its value, decay law
- b) Interaction of α-, β– and γ-radiation with matter

18. 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

19. Methods in isotope diagnostics

a) Isotope accumulation curve; effective and biological half life
b) Gamma camera (structure and operation); static and dynamic pictures
c) SPECT, PET

20. Absorption of ionizing radiation in tissues

a) Types of ionizing radiation and their absorption characteristics
b) Devices based ion gas ionization used for the detection of ionizing radiation

21. Detection of ionizing radiation

a) Scintillation counter
b) Thermoluminescent dosimeter

22. Dosimetry of ionizing radiation

a) Absorbed dose (definition, unit, validity)
b) Exposure, (definition, unit, validity);
c) Measurement of exposure

23. Quantitative characterization of biological effects of ionizing radiation

a) Equivalent dose effective dose; weighting factors
b) Characteristics of stochastic and deterministic damages, ALARA principle

24. Boltzmann-distribution and its applications

a) The physical law and its significance
b) Applications of law, examples

25. 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

26. Generation and detection of ultrasound

a) Generation and detection of US
b) US techniques, echo principle

27. Ultrasound imaging

a) US image and its interpretation
b) A-, B- and (T)M images

28. Doppler method; US therapy

a) Doppler effect and its medical application
b) Biological effects of US

29. Basic principles of ECG

a) Heart muscle as source of electric signal
b) Electrodes and lead systems in ECG
c) Einthoven-triangle, integral vector

30**. Absorption spectrometry**

a) Beer's law and its medical application
b) Types of spectra, characteristics, information obtained from the spectra

31. Absorption spectrophotometer

a) Measuring techniques: light sources, monochromators, detectors
b) Parts of two-beam spectrophotometer

32. Application of fluorescence spectroscopy for structural and dynamic examinations

a) Fluorescence lifetime, Perrin-equation and its parameters
b) Fluorescence quenching and conclusions from it
c) FRET (conditions, conclusions)

33. Basic principles of NMR and ESR spectroscopy

a) The spin and the magnetic momentum, splitting of energy levels in outer magnetic field
b) Parts of NMR spectrometer
c) Applications of NMR spectroscopy

34. 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)

35. 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

36. 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

37. . 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

38. Diffusion

a) Fick's first law; diffusion coefficient

b) Generalized continuity-equation; Fick's second law and its meaning

39. 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 (alveolocapillar oxygen diffusion)

40. Osmosis; osmotic phenomenon

a) Explanation of the osmotic pressure; van't Hoff law

b) Problems of osmotic pressure in practice; isotonic solutions

41. Thermodynamic aspects of transport processes

a) Thermodiffusion; heat conduction

b) Thermodynamic systems, extensive and intensive quantities, states, processes

42. Uniform description of transport processes;

a) Similarities of transports

b) Onsager-relation, equilibrium

43. Human body as an open thermodynamic system

a) Thermodynamic system and its environment, zeroth law of thermodynamics

b) I. law of thermodynamics, extended form, chemical potential, electrochemical potential

44. Direction of processes in non-isolated systems

a) II. law of thermodynamics, entropy (properties, statistical interpretation), III. law of thermodynamics

b) Thermodynamic potentials and application of them

45. Interpretation of resting membrane potential

a) Membrane permeability constant; diffusion of molecules; electrodiffusion across membrane

b) Equilibrium model and electrodiffusion (transport) model

c) Equivalent circuit model of cell membrane

d) Local changes of membrane potential

46. Action potential

a) Action potential; ion transport during action potential

b) Depolarization threshold and its changes during action potential

47. Biophysics of sensory function I.

a) Types of stimuli and modalities

b) Types of receptors

c) psyho-physical laws

48. Biophysics 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

49. Biophysics of hearing

a) Ear as sensory organ

b) Signal transduction during hearing

c) Function of basal membrane and hairy cells in the analysis of mechanical stimuli

50. Biophysics of vision

a) Optical imaging in the eye

b) Properties and role of rods and cones

c) Basic principles of color vision

51. Biophysics of vessel system

a) Biophysical parameters of blood, determinants of blood viscosity.

b) Blood vessels as tubes connected parallel and in series

c) Biophysical parameters in blood vessels, auxiliary factors of circulation.

52. Biophysics of heart function

a) The cardiac cycle, changes of pressure and flow and the state of heart valves during the heart cycle

b) Pressure – volume diagram of the left ventricle, work of the heart.

53. Structure and function of muscles

a) Muscle types, sarcomere

b) Filament systems of sarcomere, function of sarcomeric filaments

54. Basic principles of contraction of striated muscles

a) Sliding filament theory

b) „Cross-bridge" theory

c) Regulation of muscle function

55. Cytoskeletal system

a) Filaments of cytoskeletal system

b) Polymerization equilibria in the cytoskeleton

c) Mechanical properties of the filaments

56. Motor proteins

a) Types of motor proteins

b) Duty cycle of motor proteins

c) Examination methods of motor proteins