Medical Biophysics II.
Final exam theoretical questions 2013.

1. Early atomic models. Rutherford-experiment. Franck-Hertz experiment. Bohr model of atom.

2. Quantum mechanical atomic model. Quantum numbers. Heisenberg's uncertainty relation.

3. Spin quantum number and significance of its application. Stern-Gerlach experiment. Electron spin resonance spectroscopy.

4. Radiation fundamentals. Radiant intensity, power.

5. Harmonic oscillation. Wave phenomena: diffraction, interference, polarization.

6. Black body radiation. Kirchhoff's laws. Stefan-Boltzmann law. Wien's displacement law. Planck's law of radiation.

7. Photoelectric effect and the significance of its application.

8. Dual nature of light. Electromagnetic spectrum.

9. Matter waves. Electron microscope, it's working principle and applications.

10. Atomic nucleus. Nuclear forces, isotopes.

11. The unstable nucleus. Alpha and beta decay.

12. Production of gamma-radiation, K-capture.

13. Radioactive decay law. Activity. Decay constant.

14. General law of radiation attenuation.

15. Interaction of radiation with matter: light reflection, refraction, scattering. Total internal reflection and its applications.

16. Light absorption. Lambert-Beer's law. Absorption spectrophotometry.

17. Ionization. The Bragg-peak and its explanation. General properties of ionizing radiations.

18. Alpha-radiation and its interaction with matter.

19. Beta-radiation and its interaction with matter.

20. Gamma-radiation and its interaction with matter.

21. Positron-radiation and its interaction with matter. Positron emission tomography (PET).

22. Mechanisms of ionizing radiation. Stochastic and deterministic effects. The ALARA principle.

23. Isotope diagnostics. Selection principles of isotopes. Half-lives.

24. Isotope diagnostic methods. Gamma camera, static and dynamic tests, scintigraphy, SPECT.

25. Dose concepts. Dosimetry.

26. Basic types of luminescence and their properties. Kasha's rule. Luminescence excitation and emission spectra. Luminescence lifetime.

27. Measurement of luminescence. Emission polarization and anisotropy.

28. Fluorescence microscopy.

29. Basic principles of lasers. Induced emission. Population inversion. Optical resonance.

30. Properties of laser light. Applications of lasers.

31. Production and properties of X-radiation. Energy spectrum of X-radiation.

32. Mechanisms of interaction of X-radiation with matter.

33. Mechanisms of X-ray image formation. Contrast agents. Principles of computed X-ray tomography (CT).

34. Multiatomic systems. Interactions and bonds.

35. Gases, liquids, solids, liquid crystals.

36. Boltzmann-distribution and its significance.

37. Biophysics of water. Anomalous properties of water.

38. Biopolymers: types, properties, global structure and elasticity.

39. Structure, elasticity and biologically relevant sizes of DNA. Structure and folding of RNA.

40. Composition and structure of proteins. Display of protein structure. Forces stabilizing protein structure.

41. Protein folding. Stability of proteins. Protein folding pathologies.

42. Scanning probe microscopy: principles of operation, types and applications.

43. Diffraction-limited imaging. Resolution and its theoretical limit.

44. Methods of biomolecular structural analysis: mass spectrometry, CD-spectroscopy. X-ray diffraction and its applications.

45. Fluorescence spectroscopy: Förster-type resonance energy transfer. Fluorescence quenching.

46. Special applications of fluorescence: FRAP, fluorescence-activated cell sorting.

47. Nuclear magnetic resonance (NMR). Fundamentals of MRI.

48. Thermodynamic systems. Extensive and intensive variables.

49. First law of thermodynamics. Internal energy and its changes.

50. Second law of thermodynamics. Entropy.

51. Statistical interpretation of entropy. Thermodynamic probability. The third law of thermodynamics.

52. Biological energy balance. Driving forces of biological reactions. Coupled reactions.

53. Ordered and disordered biomolecular systems. Relationship between entropy and the elasticity of biological macromolecules.

54. Irreversible thermodynamics. Transport processes.

55. Microscopic interpretation of transport processes. Brownian motion.

56. Diffusion and its laws.

57. Osmosis.

58. Heat conductance. Biological transport of metabolic heat.

59. Fluids. Viscosity.

60. Types and laws of fluid flow.

61. Types and properties of biological signals. Fourier's principle.

62. Amplification and filtering of biological signals. Processing of pulse signals.

63. Generation and characteristics of ultrasound.

64. Medical applications of ultrasound.

65. Action of mechanical forces on biological tissues. Biomechanics of hard tissues.

66. Biomechanics of soft tissues. Viscoelasticity.

67. The cytoskeletal system. Polymerization of cytoskeletal filaments.

68. Actin filament system. Actin-dependent biological motion.

69. Microtubular system. Microtubule-dependent biological motion.

70. Intermediate filament system.

71. Motor proteins. Duty cycle. Processivity.

72. Respiratory biophysics. The respiratory system as a tube system.

73. Respiratory cycle. Respiratory volumes and capacities. Role of surface tension in respiratory function.

74. Blood as fluid. Determinants of blood viscosity.

75. The circulatory system as a vessel system. Physical variables across the circulatory system.

76. Blood vessels as elastic tubes. Auxiliary factors of blood circulation.

77. Structure of striated muscle. Fundamental processes of striated and smooth muscle contraction.

78. Mechanisms of muscle contraction. Energetics of striated muscle.

79. Excitation-contraction coupling. Elasticity of striated muscle.

80. Electrical activity of the heart. Physical principles of the ECG.

81. The cardiac cycle. Work of the heart.

82. The resting membrane potential.

83. Changes of the membrane potential. Hyperpolarization, depolarization.

84. The action potential.

85. Sensory receptors.

86. Optics of the eye. Refractory problems and their correction.

87. Biophysics of vision. Sensitivity of the human eye. Color vision.

88. Biophysics of hearing. Signal amplification in the ear.

89. Frequency discrimination in the ear. Theories of hearing.

90. Fundamentals of physical examination. Physical interpretation of inspection, palpation, percussion and auscultation.

91. Biophysics of complex systems. Collective behavior. Tissue differentiation.