Medical Biophysics I., 2013/14
Semifinal exam theoretical questions

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.