

Examination questions
Biophysics (general medicine)
Medical Physics and informatics (dental medicine)
Valid from academic year 2023/24

Questions or their parts marked with an asterisk (*) are not for students of dental medicine. Double asterisk (**) means that the question or its part is only for dental medicine students.

1. Subatomic structure of matter (fundamental interactions, elementary particles and their properties)
2. Main features of quantum theory (particle-wave dualism, de Broglie wavelength, Heisenberg uncertainty relations)
3. Electron shell structure of the atom (electron energy levels of the hydrogen atom, quantum numbers and their meaning, Pauli's exclusion principle, excitation and ionisation)
4. Properties of the atomic nucleus (characteristic numbers, nuclide, isotope, isobar, isomer, *stability of the nucleus)
5. Types of radioactive decay (alpha, beta, gamma, electron capture, nuclear fission, examples)
6. Law of radioactive decay (explanation of the formulas, activity, becquerel, curie, half-lives)
7. Interaction of ionising radiation with matter (absorption, scattering, attenuation, attenuation coefficient, photoelectric effect, Compton scatter, electron-positron pair production, *interactions of alpha particles, beta particles and neutrons)
8. Quantities and units used to quantify ionising radiation (electron volt, LET, dose, equivalent dose, effective dose, dose rates, units)
9. *Nature of chemical bonds (molecular orbitals, covalent bond, ionic bond, dipole moment of chemical bond, hydrogen bond, van der Waals forces)
10. Viscosity of liquids (Newton's law of viscous flow, Newtonian and non-Newtonian liquids, how to measure viscosity)
11. Water and its properties (water molecule, thermodynamic properties of water, and role of water in the organism)
12. Structure of nucleic acids (general features, pairing of nitrogen bases)
13. Four levels of protein structure (including isoelectric point and denaturation)
14. *Main methods of studying the structure of proteins and DNA (namely optical methods, NMR and X-ray structural analysis)
15. Types of dispersion systems and their properties (colloids and their physical properties, gel/sol, macroheterogeneous systems, electrokinetic potential)
16. *Centrifuges, sedimentation analysis and electrophoresis (forces taking part in sedimentation, sedimentation coefficient, charged particle in an electric field, electrophoretic mobility, centrifuges)
17. Basic concepts and laws of thermodynamics (thermodynamic system, equilibrium, reversible and irreversible process, work of thermodynamic system, difference between temperature and heat)
18. Equations of state and basic thermodynamic processes (universal gas law, van der Waals equation, isothermal, isobaric, isochoric and adiabatic processes)
19. First and Second law of thermodynamics (including meaning of entropy)
20. *thermodynamic potentials - enthalpy, free enthalpy, chemical potential, chemical equilibrium and chemical work)
21. How to explain that entropy is a measure of system ordering?
22. Osmotic pressure (explain its origin, van't Hoff's formula, osmolarity, tonicity)
23. Phases and phase equilibria (Gibbs's phase rule, phase diagram, Raoult's law, Henry's law, ebullioscopy and cryoscopy)
24. Surface tension (definition, Laplace equation, Gibbs' absorption equation, surfactants and their biophysical importance, how to measure surface tension)
25. Galvanic cell (explanation, Nernst equation, **galvanic voltage in oral cavity).
26. Entropy production and the stationary state (what is the difference between stationary state and thermodynamic equilibrium, Prigogine principle, *fluctuations, *generalised Le Chatelier principle)
27. Diffusion (diffusion flux, Fick's laws, Einstein formula for diffusion coefficient)

28. Energetic processes in living organism (transformations of energy, sources of energy, why do organisms need energy)
29. Mechanical properties of solids and tissues including blood (elasticity – Hooke's law, viscoelastic and plastic-viscoelastic substances)
30. Mechanical properties of teeth and parts of the supportive-locomotor system (including muscle contraction mechanism and *bone densitometry: X-ray and ultrasonic)
31. Work done by the heart (how to calculate it?)
32. Blood flow (equation of continuity, Bernoulli's equation, Hagen-Poiseuille law, Reynolds number and critical velocity, elastic and muscular vessels, resistance of the vessel bed, how to measure blood flow, oncotic pressure and its importance for capillary filtration)
33. Biophysics of breathing (respiratory movements, breathing resistance, respiratory volumes and capacities, respiratory work, gas exchange in alveoli, spirometry)
34. Human voice and its properties (production of voice, physical properties of vowels and consonants, formants)
35. Resting membrane potential (explanation of origin, how to measure it). Nernst and Goldman equation (explanation)
36. Action membrane potential and its propagation (explanation of origin, local currents, salutatory conduction of the nerve impulse)
37. *Synaptic transfer of action potential (structure of the synapse, excitatory and inhibitory synapses, summation)
38. Electrical excitability of tissues (I/t curve, rebase, chronaxy, clinical importance, **electrical excitability of dental pulp)
39. Sensory receptors (types of receptors, receptor cells and their common features, receptor potential, Weber-Fechner and Stevens' law, adaptation)
40. Basic terms of physiological acoustics (quantities used to measure sound, sound intensity and intensity level, loudness and loudness level, hearing field)
41. Biophysical function of outer, middle and inner ear (function of drum and ossicles, structure and function of organ of Corti, Bekesy theory, *electrical phenomena in the inner ear) and biophysical function of the vestibular apparatus
42. Examination of hearing deficiencies and types of hearing aids (audiometry, audiogram, two types of hearing loss, main parts of a hearing aid, what is a cochlear implant)
43. *Basic concepts of optics (what is light, laws of reflection and refraction, refraction index, lens equation, physical properties of lenses, what is interference, diffraction and polarisation of light)
44. Sources of light and how to measure light (luminous intensity – candela, luminous flux – lumen, illuminance – lux, exposure, energy-based quantities and units)
45. Structure and optical properties of the eye (Gullstrand model, accommodation and amplitude of accommodation)
46. Ametropias (myopia, hyperopia, astigmatism and how to correct them, what is a retinal implant)
47. Retina and its function (structure, rods, cones, macula lutea, structure of photoreceptor cells, *electrical phenomena in the retina and ERG)
48. Vision (visual acuity, optotypes, depth of field, scotopic and photopic vision, *photochemical reaction of rhodopsin, *colour vision and its disorders)
49. Biophysical effects of low and high pressures (high-altitude hypoxia, decompression sickness, hyperbaric chamber)
50. *Biophysical effects of velocity changes and mechanical forces (acceleration stress, state of weightlessness, motion sickness, concussion)
51. Biophysical effects of sound and ultrasound (noise and hearing impairment, sources of ultrasound, main effects of ultrasound, cavitation, importance for medicine – ultrasound therapy)
52. Biophysical effects of temperature changes (heat exchange mechanisms, influence of air humidity, thermoregulation)
53. Biophysical effects of electric currents (tissue impedance and conductance, electric shocks (injuries) and how to avoid them)

54. *Magnetic fields and their biophysical effects (types of magnetic fields, magnetic permeability, possible effects of magnetic fields on human organism and their applications in therapy)
 55. Non-ionising electromagnetic radiation and its biophysical effects (what is infrared, visible and ultraviolet light, polychromatic and monochromatic light, coherent and non-coherent light, action on atoms and molecules, thermal and non-thermal effects of light, photodynamic therapy)
 56. Laser and its biophysical effects (principle of laser, main types of lasers, properties of laser light, thermal and non-thermal effects of laser light, lasers in therapy)
 57. Biophysical effects of ionising radiation (direct and indirect effect, lethal doses, radiosensitivity and *biological effects of nuclear explosions and disasters)
 58. Protection against ionising radiation (physical, biological and chemical protection, give some examples of safety measures in clinical practice)
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59. Medical devices as sources of information about patient (what is a biosignal, how to record and process biosignals, what is digitisation, how to store biosignals). Monitoring and telemetry (basic terms, modulation of transmitted signals)
 60. Tonometry (what is pressure, transducers, capacity transducer, systolic and diastolic blood pressure, direct method of blood pressure measurement, Riva-Rocci method, Holter monitoring, *how is intraocular pressure measured)
 61. Temperature measurement (what is temperature, Celsius and Fahrenheit scale, mercury thermometers for medical use, bimetallic thermometer, thermistor, thermocouple, radiation thermometer)
 62. Recording of bioelectric signals (main kinds of electrodes used in electrodiagnostics, basic properties of amplifiers, how to display a bioelectric signal)
 63. Electrocardiography (electric activity of heart, description of an electrocardiogram, standard leads, *what is vectorcardiography)
 64. Electromyography, electroencephalography (including main types of EEG waves)
 65. *Magnetic signals from human body (SQUID, what is the information carried by the magnetocardiogram or magnetoencephalogram)
 66. Electrochemical analytical methods (kinds of electrodes, standard hydrogen electrode, calomel electrode, glass electrode and pH measurement, conductivity of electrolytes, what is a conductometer)
 67. *Polarography and voltametry (principle of polarography, polarogram description, tensametry)
 68. Spectrophotometry (main parts of an absorption spectrophotometer, Lambert-Beer's law, transmittance and absorbance)
 69. *Polarimetry and refractometry (optical activity, principle of a polarimeter, Abbe refractometer)
 70. Light microscopy fundamentals (scheme of compound light microscope, magnification and resolving limit, numerical aperture, immersion objectives, *spherical and chromatic aberration, *stereomicroscope)
 71. Special optical microscopes (explain the principle of phase contrast microscope, fluorescence microscope and laser scanning confocal microscope, *near field optical scanning microscope)
 72. Electron microscopy (what is electron optics, transmission electron microscope, scanning electron microscope, how to prepare a sample for TEM, what is an acoustic microscope, *STM, *AFM)
 73. Measurement of ionising radiation (personal dosimeters, thermoluminescence method, scintillation counter, *GM tube)
 74. Overview of imaging methods (advantages and disadvantages of individual methods, safety problems, algorithm of the imaging process, sensitivity and specificity)
 75. *Contactless thermography (what is a thermogram, diagnostic importance of thermography, thermography and occupational risks)
 76. Theoretical and technical basis of ultrasound diagnostics (acoustic parameters of tissues, acoustic impedance, piezoelectric transducer, attenuation of ultrasound, frequency and attenuation)
 77. A-mode and B-mode ultrasound diagnostics (A-mode, dynamic B-mode, TM-mode, types of transducers, importance of impulse repetition frequency)
 78. Doppler flow-meter and combined methods (Doppler frequency shift, CWD, PWD, what is the duplex method and colour flow mapping)
 79. *Sonography in clinical practice (ultrasound echo-contrast agents, safety of diagnostic ultrasound, TI, MI, advantages and disadvantages of sonography)

80. Endoscopy (mirrors and endoscopes with rigid tubes, fiber-optic endoscopes and videoendoscopes, construction and clinical importance)
81. Theoretical and technical basis of X-ray diagnostics (attenuation of X-rays, main parts of X-ray device, X-ray tube, bremsstrahlung and characteristic radiation)
82. Origin of X-ray image (passage of X-rays through the body, importance of collimators, filters and grids, image blur and how to reduce it, contrast agents, how to check quality of an X-ray image)
83. Image intensifier (construction and clinical importance, patient X-ray exposure and how to reduce it)
84. **X-ray devices in dentistry (dental X-ray apparatus, panoramic images (OPG), cone beam CT, safe use)
85. Computed tomography (how it works, Hounsfield numbers, clinical importance, patient exposures)
86. Diagnostic use of radionuclides in medicine (gamma camera, SPECT, PET, clinical importance, safety problems)
87. Nuclear magnetic resonance (magnetic moment of nucleus, Larmor precession, origin of NMR signal, relaxation times, *contrast agents, *NMR-spectroscopy)
88. Magnetic resonance imaging (origin of NMR signal, magnetic field gradients in image acquisition, clinical value of MRI, safety problems in MRI)
89. Extracorporeal shock-wave lithotripsy (what are the shock-waves and how to produce them, construction of a lithotripter, clinical importance and safety problems, *laser lithotripsy, *shock-wave therapy)
90. Electrotherapy (iontophoresis, galvanisation, apparatuses and methods for electrostimulation of various organs, *magnetotherapy)
91. Thermotherapy (hydrotherapy and other methods based on heat transfer, thermal effects of high-frequency electric currents, how to apply them)
92. Accelerators used in medicine (principles of cyclotron and linear accelerator, clinical importance)
93. Nuclear radiation in therapy (caesium and cobalt “bomb”, afterloading and other therapeutic applications of radionuclides)
94. Methods of radiotherapy (simulators, brachytherapy and teletherapy, fractionation, clinical importance)
95. Physical principles of modern surgical instruments (electrosurgery, lasers in surgery, ultrasound surgery, cryosurgery, water jet surgery)
96. Artificial heart and lungs (cardiopulmonary bypass, breathing assist device, heart assist devices and artificial heart)
97. Artificial kidney (what is dialysis, haemodialyser and its construction, *peritoneal dialysis, *haemofiltration)
98. **Biocompatibility of materials used in dental medicine, properties of materials for dental prostheses and implants
99. ** Rotary instruments and lever tools in dental medicine. Ultrasonic and sonic devices in dental medicine.
100. Common computer architecture (CPU, von Neumann scheme, how does the CPU work, peripherals of a PC - input and output devices)
101. Define the Internet, provide examples and explain possible use of some services used in this network (World Wide Web, e-mail, Internet Relay Chat, Telnet, FTP, etc.) in health care.
102. What is the definition and role of medical informatics in today’s health care, provide some examples, explain the concept of telemedicine.
103. What is evidence based medicine a how to search for evidence using the Web?
104. What is information and how to calculate its amount? Give an example.
105. Transmission of signals in information channels, coding, noise, redundancy
106. What is positive and negative feedback, what is the difference between controlled and regulated systems, what is an automaton?
107. Examples of nanomedical devices