Physics

List of possible questions (10 will be selected – max. one from each group):

1a: List all basic units of the SI system (with their exact definitions).

1b: Describe basic 4 physical interactions (forces) together with their force carriers.

1c: Explain the role of basic physical constants and give their approx. values (universal gravitational constant, electric permittivity of vacuum, magnetic permeability of vacuum, speed of light, Boltzman constant, Avogadro constant, Planck constant).

2a: Explain the first Newton's law of motion.

2b: Explain the second Newton's law of motion.

2c: Explain the third Newton's law of motion.

3a: Define basic parameters in mechanics – velocity, acceleration, angular velocity, force, momentum, moment of force.

3b: Define basic parameters in mechanics – force, pressure, work, power, moment of inertia.

3c: Define and describe fundamental types of mechanical energy.

4a: Explain three Kepler's laws.

4b: Explain Newton's gravitational law

4c: Explain properties of free fall (basic equations, shapes of orbits in gravitational field).

5a: Describe various mechanical oscillators.

5b: Describe mechanical waves, write the basic form of wave equation.

5c: Describe Huygens principle, interference of waves and Doppler effect.

6a: Explain the basic properties of ideal gas and list its state variables.

6b: Write the state equation for ideal gas (ideal gas law) and explain all parameters.

6c: Explain three laws of thermodynamics.

7a: Explain thermodynamic temperature and other temperatures scales.

7b: Explain basic processes in ideal gas (isothermal, isochoric, isobaric and adiabatic).

7c: Explain basic mechanisms of heat transfer (give examples from nature).

8a: Define Coulomb's law and explain all parameters. Explain the triboelectric effect.

8b: Define the electric voltage and potential. Define the unit volt.

8c: Define the electric current and current density. Define the basic SI unit ampere.

9a: Define electric flux and Gaussian law.

9b: Describe electrical dipole and give the formula for its potential.

9c: Give Ohm's law, explain electric resistance and conductance.

10a: Explain electric resistivity and conductivity, give the continuum equation.

10b: Explain properties of dielectric material and function of a capacitor.

10c: Explain impedance and admittance for alternating current (and basic properties of AC).

11a: Describe magnetic dipole and the character of its field. Define the magnetic flux.

11b: Define magnetic intensity and induction, give the basic relation between them.

11c: Explain basic magnetic property of the material (permeability) and explain basic types of material – diamagnetic, paramagnetic and ferromagnetic.

12a: Explain magnetic hysteresis.

12b: Explain concept of magnetic domains.

12c: Explain Curie's temperature.

13a: Define Lorentz force law (with the right hand rule for magnetic force direction).

13b: Define the Biot-Savart law (with the right hand rule for the magnetic induction direction).

13c: Define the Amper's law and Faraday's law of induction.

14: Give Maxwell's equations in integral or differential form.

15a: Explain the character of EM waves (with the right hand rule for wave description).

15b: Explain the role of Poynting vector in EM waves description.

15c: Explain the known EM spectrum, define the limits of visible light wavelengths.

16a: Explain basic properties of light reflection and refraction (and diffraction).

16b: Explain properties of different types of lenses and mirrors (explain optical microscope).

16c: Explain the black body radiation.

17a: Give Einstein’s two postulates of Special Theory of Relativity.

17b: Explain the Lorentz transformations equations (time dilation and length contraction).

17c: Explain relativistic momentum and mass, give the known relation between mass and energy.

18a: Explain the spacetime diagram and light cone.

18b: Explain tenets of General Theory of Relativity and principle of equivalence.

18c: Explain properties of spacetime (curvature, gravitational lensing, etc.).

19a: Explain Thomson’s, Rutherford’s, Bohr’s and orbital models of atom.

19b: Describe properties of nucleons and basic experiments of their detection.

19c: Explain photoelectric effect and Plank’s (Einstein’s) interpretation.

20a: Explain the Heisenberg's uncertainty principle and write the Schrödinger‘s equation..

20b: Give the basic elements of The Standard Model (elementary particles categories and force carriers).

20c: List four radioactive series and 3 basic types of radiation.

List of possible exercises (3 will be selected):

1. Evaluate maximum height and appropriate timings in a case, when a body was thrown up with some initial speed.

2. Find amplitude, period, frequency and amplitude – from a given equation for a case of harmonic oscillator.

3. Find the molar mass of gas when there are given its temperature, pressure and density (try to estimate the type of gas).

4. Compare the electrical and gravitational forces acting between two electrons placed in vacuum in a very small distance.

5. What are the forces acting between two electrically charged spheres, if these are placed in various environments (electric charges and distance between them are given).
6. What is the magnetic induction in vacuum in a small distance from very long straight wire, when the current is given?
7. What is the relative speed of two electrons (moving with the same given speed in opposite directions).
8. What must be the voltage of electric field to accelerate an electron which, if collided with hydrogen atom, moves it to the first exciting state?