PHYSICS 2020
Version A

Note: We do not consider any relativistic effects in the test questions unless otherwise stated. The frame of reference (co-ordinate system), in case one is needed, is inertial and connected with the observer. In the questions oriented on mechanics we consider incompressible solids and liquids unless otherwise stated. The gravitational field is homogeneous. In optics-oriented questions all lenses are considered thin and the light rays are paraxial. Use 3.14 as the value of π. Express the results as round numbers with three significant digits (figures).

1. One of the following sets of units contains *only base (fundamental) and/or derived* SI *units*.
a) second, joule, candela, mole, newton
b) electron volt, second, ampere, newton, mole
c) hour, mole, kilogram, candela, kelvin
d) kelvin, candela, minute, radian, gram
e) No answer is correct.

2. Which of the following sets of quantities contains only vectors?
a) acceleration, acoustic power, magnetic field (induction)
b) pressure, trajectory, capacitance
c) impulse of force, magnetic field (induction), momentum
d) moment of force, electric charge, pressure
e) No answer is correct.

3. Which of the following units is the unit of dioptric power?
a) m^{-1}
b) only number
c) m
d) rad^{-1}
e) No answer is correct.

4. Which of the following units is correctly substituted by a combination of other units?
a) tesla $[V \cdot A]$
b) joule $[kg \cdot s^{-2}]$
c) watt $[J \cdot s^{-1}]$
d) decibel $[Pa \cdot m^{-1}]$
e) No answer is correct.

5. Which of the following units is only a number (i.e. belongs to a dimensionless quantity)?
a) becquerel
b) radian
c) mol
d) dioptre
e) No answer is correct.

6. A body is thrown normally upwards directly from the surface of a small planet ($a_g = 3.00$ m·s^{-2}), and reaches maximum altitude of 6.00 m. What is the initial speed of this body? (The planet has no atmosphere!)
a) 18.0 m·s^{-1}
b) 12.0 m·s^{-1}
c) 6.00 m·s^{-1}
d) 5.24 m·s^{-1}
e) No answer is correct.

7. A guided missile of 500 kg fires for 5.00 s its rocket engine which exerts a constant thrust force of 10.0 kN. How much will the speed of the missile change? (The procedure happens in vacuum and state of weightlessness; the missile mass does not change.)
a) 50 m·s^{-1}
b) 100 m·s^{-1}
c) 1000 m·s^{-1}
d) There is not enough data to calculate the speed change.
e) No answer is correct.

8. A weather balloon of 12.0 m^3 volume and 10.0 kg mass (incl. the gas inside) ascends normally upwards under windless conditions at a constant velocity of 2.00 m·s^{-1}. What is the net force exerted on the balloon against the direction of its movement? (air density is 1.00 kg·m^{-3}, gravitational field or acceleration $a_g = 10.0$ m·s^{-2})
a) It cannot be calculated since we do not know what the size and correct shape of the balloon is.
b) 1.20 N
c) 12.0 N
d) 120 N
e) No answer is correct.

9. The electric motor of a crane in a container transshipment point has a power of 200 kW. The container moves upwards at a constant speed of 2.00 m·s^{-1}. What is the force exerted by the motor on the lifted container?
a) It cannot be calculated because we do not know the time necessary for lifting of the container.
b) 400 kN
c) 200 kN
d) 100 kN
e) No answer is correct.

10. A body is in a circular uniform motion at a speed of 100 m·s^{-1}. Its trajectory is a circle with a radius of 3.00 m. What is the frequency of this circular motion?
a) 1.33 Hz
b) 5.31 Hz
c) 10.62 Hz
d) 16.7 Hz
e) No answer is correct.

11. Two heavy spheres hanging on long ropes, which centres were originally in distance of $r = 40$ cm, have changed their mutual position in such a way that their centres are in distance of $r = 20$ cm now. The force of gravity acting between the spheres increased by factor of:
a) 1   b) 2   c) 4   d) 16   e) No answer is correct.

12. Table-tennis balls are ascending at a constant speed towards the water surface (they were released by a diver some meters below the water surface). We suppose that the balls are under the action of buoyancy. We can say that the force of buoyancy during the ascent (the balls are considered incompressible)**:**
a) is zero because they move freely.
b) remains constant.   c) increases.   d) decreases.   e) No answer is correct.

13. A flat metallic block and a sphere made of the same metal are on the bottom of a vessel filled by water. Both bodies are of the same mass. It is true that
a) the block will be buoyed up more than the sphere.   b) the sphere will be buoyed up more than the block.
c) a horizontally oriented flat block will be buoyed up more than the block standing on its „edge".
d) the sphere will be buoyed up also by the surface tension.   e) No answer is correct.

14. Water is flowing through a horizontal pipe or varying radius. If the ratio of radii of the pipe in the narrower and broader part is 1:3, the ratio of water stream speeds in these two parts must be:
a) 9:1   b) 1.5:1   c) 3:1   d) 1:1.5   e) No answer is correct.

15. A body hanging on a string oscillates harmonically without damping (moving up and down with a constant amplitude). The body reaches the maximum speed just when
a) its displacement (measured from the equilibrium position) equals the square root of the oscillation amplitude.
b) the body reaches maximum acceleration.   c) its displacement equals just the amplitude.
d) the body reaches minimum displacement (measured from the equilibrium position).
e) No answer is correct.

16. If we change the term φ (i.e. the initial phase angle) in the equation describing the displacement y of a harmonically oscillating body, the oscillating body displacement y can reach its maximum value (the amplitude). Such a change of φ equals for *any y* for example:
a) $\pi/2$ b) π c) $3\pi/2$ d) 2π e) No answer is correct.

17. A sound of 1 kHz frequency has at a given place an intensity value of 10^{-6} W·m^{-2}. What is the sound level of this sound (consider the value of threshold sound intensity $I_0 = 10^{-12}$ W·m^{-2})?
a) -6.00 dB   b) 6.00 dB   c) 18.0 dB   d) 60.0 dB   e) No answer is correct.

18. Choose the true statement about sound and ultrasound. (Their sources are in rest in relation to the ambient medium.)
a) Ultrasound travels in water at the highest speed at all.   b) Ultrasound waves are always transverse.
c) Ultrasound can travel by both transverse and longitudinal waves in solids.
d) The sound wavelength is always shorter than the ultrasound wavelength.   e) No statement a) to d) is true.

19. The term pV, where p is gas pressure, and V its volume, has the same unit as:
a) mass (of the gas)   b) force   c) energy   d) Avogadro constant   e) No answer is correct.

20. Find a thermodynamic process during which no mechanical work can be done (ideal gas amount dos not change)**?**
a) isothermal   b) isobaric   c) isochoric (or isosteric)   d) adiabatic
e) No answer is correct.

21. The pressure of an ideal gas increased three-times during an isothermal process in a vessel closed by a movable piston. It resulted in

a) increase of its volume by the factor of 3.   b) decrease of its volume by the factor of 9.
c) increase of its volume by the factor of 9.   d) decrease of its volume by the factor of 3.
e) No answer is correct.

22. Pure water becomes ice at a temperature different from 0 ºC. This phenomenon is probably caused by
a) increased evaporation.   b) lowered evaporation.
c) changed (not normal atmospheric) external pressure.
d) presence of SiO_2 crystals in the vessel with water.   e) No answer is correct.

23. It is possible to place a steel needle on the water surface, and the needle will not sink. One of the following phenomena can be explained on similar basis.
a) capillary depression   b) the turbulent streaming of water.
c) noise arising when water flows quickly through a narrow pipe.
d) liberation of bubbles after opening a bottle of soda.   e) No answer is correct.

24. A metallic bar of 100 mm² cross-section area becomes longer by 0.10 % due to action of 10 kN force. What is the coefficient (modulus) of elasticity of the metal the rod is made of?
a) 10.0 MPa   b) 100 MPa   c) 10.0 GPa   d) 100 GPa   e) No answer is correct.

25. Intensity of a homogeneous electric field existing between the plates of a capacitor (at a constant voltage) is always
a) directly proportional to the relative permittivity of dielectric between the plates.
b) not influenced by the relative permittivity of dielectric between the plates.
c) indirectly proportional to the potential difference between the plates.
d) indirectly proportional to the relative permittivity of dielectric between the plates.   e)   No   answer   is correct.

26. There are three identical capacitors, each of 300 nF capacitance. What can be the resulting capacitance if we wire them in all possible combination ways (in series, in parallel or in another combination)?
a) 60 nF   b) 1 200 nF   c) 450 nF   d) 600 nF   e) No answer is correct.

27. The constant direct current flowing through a resistor is 50.0 mA at a voltage of 5.00 V. What is the time necessary for the transfer of 3.00 C electric charge?
a) 250 s   b) 60.0 s   c) $6.00 \cdot 10^{-3}$ s   d) more than 5 minutes
e) No answer is correct.

28. Two close parallel wire carrying electric currents of the opposite direction are
a) attracted.   b) repulsed.   c) exerting mutual force only the current is alternating.
d) never exerting mutual force when the current is alternating.   e) No answer is correct.

29. The formula for calculation of the impedance $Z = \sqrt{R^2 + \left(\omega L - \dfrac{1}{\omega.C}\right)^2}$ **can be used for a circuit**

a) with a resistor, solenoid and capacitor connected in series.
b) with a resistor and solenoid connected in series, and a resistor connected in parallel to them.
c) with a resistor, solenoid and capacitor connected in arbitrary way.
d) with a resistor, solenoid and capacitor connected in parallel.   e) No answer is correct.

30. The NP and PN junctions in series form a semiconductor circuit element functioning as
a) LED diode.   b) thermistor.   c) alternator.   d) transistor.
e) No answer is correct.

31. The light rays travelled towards a lens with dioptric power of –8 D parallelly with its principal axis. What is the distance (measured from the centre of the lens) of the single point in which the rays (really or virtually) intersect?
a) –8.00 cm   b) –8.00 m   c) –12.5cm   d) +12.5 cm   e) No answer is correct.

32. The light rays travel through a converging lens and intersect in a single point on principal axis of the lens 80 cm in distance from the centre of the lens. This distance is twice of its focal length. The point source of these rays is located on the principal axis of the lens

a) between the object focus and the lens.   b) 0.4 m in distance from the centre of the lens.

c) 0.8 m in distance from the centre of the lens.   d) The problem cannot be solved based on given data.

e) No answer is correct.

33. In some hypothetical physical process a part of energy of a blue light photon (λ = 450 nm) was transformed in some other form of energy. Finally, as a result of this process,

a) the resulting photon can represent yellow light.

b) the resulting photon can represent the violet light.   c) No change of light colour will happen.

d) It is a nonsense; such processes are impossible.   e) No answer is correct.

34. The unit of luminous flux is:

a) lux   b) candela   c) $W \cdot m^{-2}$ d) lux second   e) No answer is correct.

35. The isotopes of carbon differ in:

a) principal quantum number.   b) number of neutrons in the nucleus.

c) numbers of electrons in the electron shells.

d) numbers of protons in the nucleus.   e) No answer is correct.

36. If the number of protons inside an atom nucleus lowers by one, it is possible that the nucleus emitted only this single particle (except of neutrinos and antineutrinos)**:**

a) α b) β^+ c) β^- d) muon   e) No answer is correct.

37. In the formula for the law of radioactive decay ($N_t = N_0 \cdot e^{-\lambda \cdot t}$) the right meaning of symbol „λ" is

a) half-life time of the decay.   b) wavelength of the emitted gamma rays.   c) the decay constant.

d) Becquerel constant.   e) No answer is correct.

38. Which of the following particles *cannot* be (after initial acceleration) set in circular motion by a homogeneous magnetic field?

a) α-particle   b) neutron   c) proton   d) positron   e) No answer is correct.

39. The so-called de Broglie matter waves

a) are manifestation of quantum properties of photons.   b) are oscillations of electromagnetic field.

c) are only another name for Heisenberg relation of uncertainty.

d) characterise the wave properties of particles.   e) No answer is correct.

40. A specific property of the characteristic x-ray radiation is its:

a) coherence and convergence.   b) high intensity.   c) very short wavelength.

d) reduction to a small number of narrow bands of wavelength (spectral lines).

e) No answer is correct.