UNIVERSITY ENTRANCE EXAMINATION

PHYSICS

Duration : 2 hours

Please read the following instructions carefully.

1. This paper is made up of 50 Multiple-Choice questions and comprises ELEVEN (11) printed pages.

2. Do not write on the question paper.

3. Answer all questions and indicate your answers on the answer sheet provided. Marks will not be deducted for wrong answers.

4. Do not take any paper, including the question paper or unused answer sheets, out of the examination hall.
Multiple-Choice Questions

Answer all questions in this section.

1. The mass of an isotope of uranium $^{238}_{92}U$ is 238.05 g mol$^{-1}$. Its density is 19.1 g cm$^{-3}$ at room temperature. Which of the following is closest to the number of $^{238}_{92}U$ atoms in 1 cm$^3$ of this isotope?
   A  2.53x10$^{21}$
   B  3.29x10$^{22}$
   C  4.83x10$^{22}$
   D  6.02x10$^{23}$
   E  7.51x10$^{24}$

2. An isotope of plutonium $^{239}_{94}Pu$ decays by alpha emission. Which of the following is the decay product?
   A $^{243}_{96}Cm$
   B $^{235}_{94}Pu$
   C $^{239}_{93}Np$
   D $^{235}_{92}U$
   E $^{234}_{90}Th$

3. A compact disc of diameter 120 mm is spinning at a speed of 500 revolutions per minute. Which of the following is closest to the linear speed of the outer edge of the disc?
   A  0.50 m s$^{-1}$
   B  1.0 m s$^{-1}$
   C  1.6 m s$^{-1}$
   D  3.1 m s$^{-1}$
   E  60 m s$^{-1}$

4. A steel wire is stretched and clamped between two fixed points that are spaced 1.0 m apart. Which of the following is closest to the fundamental wavelength that can exist on this wire?
   A  0.25 m
   B  0.50 m
   C  1.0 m
   D  2.0 m
   E  4.0 m

5. A thin converging lens of focal length 20 cm is used to shape light from a lamp filament into a parallel beam. Which of the following is closest to the required distance between the lamp filament and the lens?
   A  5.0 cm
   B  10 cm
   C  20 cm
   D  40 cm
   E  80 cm
6. A metallic sphere of radius 1.0 cm is charged with $1.0 \times 10^9$ electrons in air. Which of the following is closest to the electric potential difference between the surface of this sphere and a point far away? [The electric potential of a charged metallic sphere varies with distance $r$ from the centre of the sphere according to $V = \frac{1}{4\pi \cdot \varepsilon_0} \frac{q}{r}$ for $r \geq r_o$, where $r_o$ is the radius of the sphere.]

A 70 V  
B -70 V  
C 140 V  
D -140 V  
E $8.99 \times 10^{20}$ V

7. Which of the following is closest to the wavelength of an electron of energy 1.0 eV?

A 1.2 nm  
B 15 nm  
C 50 nm  
D 350 nm  
E 1240 nm

8. Which of the following is most suitable to measure the temperature of red hot molten steel?

A bimetallic strip thermometer  
B thermocouple  
C optical pyrometer  
D mercury-in-glass thermometer  
E silicon diode thermometer

9. Which of the following is closest to the mean distance between air molecules at room temperature and pressure (298 K and 101325 Pa)? Assume air is made of 79% N$_2$ and 21% O$_2$ by moles.

A 0.4 nm  
B 4 nm  
C 40 nm  
D 400 nm  
E 4 µm

10. The linear thermal expansion coefficient of invar is $1.3 \times 10^{-6}$ K$^{-1}$. Which of the following is closest to the change in length of a 10-cm-long invar rod subjected to a change in temperature of +100ºC?

A +0.13 µm  
B +1.3 µm  
C +13 µm  
D +130 µm  
E +1.3 mm
11. A typical capacitor in an MP3 player has $C = 0.10 \mu F$. If a voltage of 12.0 V is placed on the capacitor, what is the charge on it?

A 1.2 µC  
B 120 µC  
C 1.2 C  
D 120 C  
E $1.2 \times 10^8$ C

12. A long, straight wire of length 1.4 m carries a current of $i = 3.5\ A$. If a magnetic field of magnitude $B = 1.5\ T$ is directed parallel to the wire, what is the magnitude of the force on the wire?

A 7.4 N  
B 6.7 N  
C 5.2 N  
D 3.7 N  
E 0 N

13. Two point charges are separated by a distance $r$. If the separation is reduced by a factor of $3/2$, by what factor does the electric potential between them change?

A $3/2$  
B $2/3$  
C $9/4$  
D $4/9$  
E $\sqrt{3/2}$

14. The surface of the Sun has a temperature of about 6000 K. What is the root-mean-square speed of a hydrogen atom in the Sun’s atmosphere?

A 6100 m/s  
B 7900 m/s  
C 9300 m/s  
D 8600 m/s  
E 12000 m/s

15. What is the critical for total internal reflection for light travelling between diamond ($n = 2.42$) and water ($n = 1.33$)?

A 24.4°  
B 33.3°  
C 36.6°  
D 48.8°  
E 90.0°
16. A rectangular gold plate has an area of $0.40 \text{ m}^2$ at $15^\circ \text{C}$. If it is heated until its area has increased by $2.5 \times 10^{-3} \text{ m}^2$, what is the final temperature of the plate? For gold, the coefficient of expansion is $14 \times 10^{-6} \text{ K}^{-1}$.

A. $115^\circ \text{C}$
B. $145^\circ \text{C}$
C. $175^\circ \text{C}$
D. $205^\circ \text{C}$
E. $235^\circ \text{C}$

17. A pot of very cold water ($0^\circ \text{C}$) is placed on a stove with the burner adjusted for maximum heat. It is found that the water just begins to boil after 3.0 min. How much longer will it take the water to completely boil away?

A. 1.6 min
B. 3.6 min
C. 16 min
D. 18 min
E. 19 min

18. A proton with $v = 200 \text{ m/s}$ is moving through a region in which the magnetic field is $B = 2.5 \text{ T}$. If the magnitude of the force on the proton is $6.4 \times 10^{-17} \text{ N}$, what angle does the proton's velocity make with $\vec{B}$?

A. 23°
B. 35°
C. 46°
D. 53°
E. 80°

19. The work function for a metal is 5.0 eV. What is the maximum photon wavelength that can just eject an electron from the metal?

A. 750 nm
B. 500 nm
C. 250 nm
D. 125 nm
E. 100 nm

20. The number of atoms in your body is closest to

A. $1 \times 10^{36}$
B. $2 \times 10^{32}$
C. $3 \times 10^{32}$
D. $4 \times 10^{28}$
E. $5 \times 10^{24}$
21. The period of a physical pendulum can be calculated by $T = 2\pi \sqrt{\frac{l}{mgd}}$. The quantity $d$ has the unit of $m$. What is the unit of $I$?
   A $kg^{-2} \cdot m^2$
   B $kg \cdot s^2$
   C $m^2 \cdot s^{-2}$
   D $m^{-2} \cdot s^2$
   E $kg \cdot m^2$

22. Balancing the nuclear equation $^{238}_{94}Pu \rightarrow X + \alpha$
   A $X = ^{236}_{90}Th$
   B $X = ^{240}_{90}Th$
   C $X = ^{234}_{92}U$
   D $X = ^{240}_{92}U$
   E $X = ^{236}_{94}Pu$

23. A particle is moving along a straight line. The position of the particle as a function of time is $x(t) = 6 + 8t + 10t^2$. What is the average speed of the particle between $t = 1$ and $t = 2$?
   A 8
   B 18
   C 28
   D 38
   E 48

24. A soccer ball with mass 0.45 kg is initially moving with speed 2.00 m/s. A soccer player kicks the ball, exerting a constant force of magnitude 30.0 N in the same direction as the ball’s motion. Over what distance must the player’s foot be in contact with the ball to increase the ball’s speed to 4.00 m/s?
   A 0.06 m
   B 0.09 m
   C 0.12 m
   D 0.15 m
   E None of the above

25. A laboratory centrifuge makes 2000 rpm (rev/min) and produces an acceleration of $6.00g$ at its outer end. What is the acceleration at a point halfway out to the end?
   A $1.50g$
   B $3.00g$
   C $6.00g$
   D $12.00g$
   E $24.00g$
26. A student tries to raise a chain consisting of three identical links. Each link has a mass of 200 g. The three-piece chain is connected to a light string and then suspended vertically, with the student holding the upper end of the string and pulling upward. Because of the student’s pull, an upward force of 15.0 N is applied to the chain by the string. Find the force exerted by the top link on the middle link.

A  3.0 N  
B  6.0 N  
C  8.0 N  
D  10.0 N  
E  None of the above

27. What is the percent difference between your apparent weight in Singapore, near the sea level, and at the top of Mount K2, which is 8611 m above sea level?

A  0%  
B  0.07%  
C  0.13%  
D  0.27%  
E  None of the above

28. A student originally charges a fixed capacitor to have a potential energy of 1 J. If the student wishes to give the capacitor a potential energy of 4 J, then the student should

A  quadruple the potential difference across the capacitor but leave the charge unchanged.  
B  double the potential difference across the capacitor but leave the charge unchanged.  
C  double both the potential difference across the capacitor and the charge.  
D  leave the potential difference across the capacitor unchanged while doubling the charge.  
E  leave the potential difference across the capacitor unchanged while quadrupling the charge.

29. The resistivity of gold is $2.44 \times 10^{-8} \Omega \cdot m$ at a temperature of 20.0 °C. A gold wire, 1.00 mm in diameter and 37.0 cm long, carries a current of 810 mA. The power dissipated in the wire is closest to

A  1.9 mW  
B  3.3 mW  
C  4.7 mW  
D  6.1 mW  
E  7.5 mW

30. What is the root-mean-square current value for an alternating current with an amplitude of 10 A?

A  3.1 A  
B  7.1 A  
C  10 A  
D  24 A  
E  28 A
31. A standing wave is set up in a 200 cm string fixed at both ends? The string vibrates in 5 distinct segments when driven by a 120 Hz source. What is the wave speed?

A 96 m/s  
B 120 m/s  
C 160 m/s  
D 240 m/s  
E 480 m/s

32. A 18 mm wide diffraction grating has rulings of 740 lines per mm. Light is incident normally on the grating. Monochromatic light of 555 nm wavelength is used. The largest angle from the normal at which an intensity maximum is formed is closest to

A 47°  
B 49°  
C 51°  
D 53°  
E 55°

33. A laser pulse of duration 25 ms has a total energy of 2.0 J. If the wavelength of this radiation is 481 nm, how many photons are emitted in one pulse?

A 4.8x10^{18}  
B 5.8x10^{19}  
C 1.2x10^{20}  
D 1.9x10^{17}  
E 3.8x10^{17}

34. An electron’s de Broglie wavelength is 5.0 \mu m. What is its speed?

A 1.5x10^2 m/s  
B 8.0x10^2 m/s  
C 1.2x10^3 m/s  
D 4.0x10^6 m/s  
E 4.0x10^7 m/s

35. The decay chain that leads from \(^{238}\text{U}\) to \(^{206}\text{Pb}\) consists a series of alpha decays and beta decays. How many beta particles are emitted?

A 4  
B 5  
C 6  
D 7  
E 8
36. The decay constant of a radioactive nuclide is $2.1 \times 10^{-3} \text{s}^{-1}$. The half-life of the nuclide, in minutes, is closest to

A. 3.1
B. 4.3
C. 5.5
D. 6.7
E. 8.0

37. In general, if a vector $\mathbf{A}$ is to be subtracted from a vector $\mathbf{B}$ the magnitude of the resultant when $\mathbf{A} \geq \mathbf{B}$

A. must equal $\mathbf{A} + \mathbf{B}$.
B. must equal $\mathbf{A} - \mathbf{B}$.
C. may be between $\mathbf{A}$ and $\mathbf{A} + \mathbf{B}$.
D. may be between $\mathbf{B} - \mathbf{A}$ and $\mathbf{B} + \mathbf{A}$.
E. may be between $\mathbf{A} - \mathbf{B}$ and $\mathbf{A} + \mathbf{B}$.

38. A train starts from rest and accelerates uniformly, until it has traveled 6.10 km and acquired a velocity of 23.0 m/s. The train then moves at a constant velocity of 23.0 m/s for 450 s. The train then slows down uniformly at 0.0650 m/s$^2$, until it is brought to a halt. The acceleration during the first 6.10 km of travel, is closest to

A. 0.043 m/s$^2$
B. 0.049 m/s$^2$
C. 0.054 m/s$^2$
D. 0.060 m/s$^2$
E. 0.065 m/s$^2$

39. An object is moving in a circle at constant speed $v$. The magnitude of the rate of change of momentum of the object

A. is proportional to $v^3$.
B. is proportional to $v^2$.
C. is proportional to $v$.
D. is a nonzero constant independent of $v$.
E. is zero.

40. An object undergoing simple harmonic motion has an amplitude of 2.3 m. If the maximum velocity of the object is 14 m/s, what is the object’s angular frequency?

A. 4.9 rad/s
B. 5.5 rad/s
C. 5.8 rad/s
D. 6.1 rad/s
E. 6.7 rad/s
41. A car accelerates uniformly from 10 to 20 ms$^{-1}$ in a distance of 150 m; How long after that will it reach 40 ms$^{-1}$?

A 40 s.
B 20 s.
C 45 s.
D 15 s.
E 30 s.

42. A parachuter of mass 75 kg falls towards the earth at a speed of 25 ms$^{-1}$. What is the resultant force acting on the person?

A 750 N.
B 450 N.
C 1,350 N.
D No net force.
E 1,500 N.

43. Light travels at different speed through different materials. If it travels at speed $c_1$ in a medium of refractive index 1.2, what is its speed in a medium of refractive index 1.6?

A $1.3c_1$.
B $0.67c_1$.
C $2c_1$.
D $1.7c_1$.
E $0.55c_1$.

44. Speed of sound in air is 340 ms$^{-1}$. A shot is fired and the echo is heard 2 s after the shot was fired. How far is the reflecting surface?

A 340 m.
B 680 m.
C 170 m.
D 85 m.
E 34 m.

45. The oscillation of a pendulum is simple harmonic when the amplitude is small compared to its length. This is because:

A a long pendulum loses less energy.
B the restoring force is proportional to displacement at small angles.
C friction of the pivot is smaller when the pendulum is long.
D a long pendulum is more massive.
E it has a higher length to mass ratio.
46. A coil of wire stores energy in the form of
   A charge.
   B potential difference.
   C magnetic field.
   D A and B.
   E A and C.

47. The angular frequency of a wave is $2000\pi$ and its phase velocity is $320\text{ms}^{-1}$. Its period is
   A $10^{-3}\text{s}$.
   B $5\times10^{-4}\text{s}$.
   C $10\text{ms}$.
   D $100\mu\text{s}$.
   E $0.05\text{s}$.

48. A motor has both resistance and inductance. A motor rated at 1 hp input operating at 240V draws 4 A of current because
   A power is lost due to resistance.
   B magnetic saturation robs power.
   C inductance does not consume power.
   D friction in the bearings of the motor.
   E A and B.

49. A sinusoidal alternating current is fullwave rectified. The rectified current will produce in the same load
   A the same power.
   B 0.71 times the power.
   C 1.41 times the power.
   D half the power.
   E twice the power.

50. Capacitance is measured in
   A Farads.
   B Henrys.
   C Ohms.
   D Pascal.
   E Watts.