Physices

12P/218/29 Question Booklet No. 627

(To be filled up by the candidate by blue/black ball-point pen)

Roll No. | | | | | | | | |

Roll No.
(Write the digits in words) ....

Serial No. of OMR Answer Sheet ....

Day and Date ....
(Signature of Invigilator)

INSTRUCTIONS TO CANDIDATES

(Use only **blue/black ball-point pen** in the space above and on both sides of the Answer Sheet)

1. Within 10 minutes of the issue of the Question Booklet, check the Question Booklet to ensure that it contains all the pages in correct sequence and that no page/question is missing. In case of faulty Question Booklet bring it to the notice of the Superintendent/Invigilators immediately to obtain a fresh Question Booklet.
2. Do not bring any loose paper, written or blank, inside the Examination Hall *except the Admit Card without its envelope.*
3. A separate Answer Sheet is given. *It should not be folded or mutilated. A second Answer Sheet shall not be provided. Only the Answer Sheet will be evaluated.*
4. Write your *Roll Number and Serial Number of the Answer Sheet by pen* in the space provided above.
5. **On the front page of the Answer Sheet, write by pen your Roll Number in the space provided at the top, and by darkening the circles at the bottom. Also, wherever applicable, write the Question Booklet Number and the Set Number in appropriate places.**
6. No overwriting is allowed in the entries of Roll No., Question Booklet No. and Set No. (if any) on OMR sheet and also Roll No. and OMR Sheet No. on the Question Booklet.
7. Any change in the aforesaid entries is to be verified by the invigilator, otherwise it will be taken as unfair means.
8. Each question in this Booklet is followed by four alternative answers. *For each question, you are to record the correct option on the Answer Sheet by darkening the appropriate circle* in the corresponding row of the Answer Sheet, by ball-point pen as mentioned in the guidelines given on the first page of the Answer Sheet.
9. For each question, darken only one circle on the Answer Sheet. If you darken more than one circle or darken a circle partially, the answer will be treated as incorrect.
10. *Note that the answer once filled in ink cannot be changed.* If you *do not wish to attempt* a question, leave all the circles in the corresponding row blank (such question will be awarded zero mark).
11. For rough work, use the inner back page of the title cover and the blank page at the end of this Booklet.
12. Deposit *only the OMR Answer Sheet* at the end of the Test.
13. You are not permitted to leave the Examination Hall until the end of the Test.
14. If a candidate attempts to use any form of unfair means, he/she shall be liable to such punishment as the University may determine and impose on him/her.

[उपर्युक्त निर्देश हिन्दी में अन्तिम आवरण-पृष्ठ पर दिये गए हैं]

12P/218/29

No. of Questions/प्रश्नों की संख्या : 150

Time/समय : 2½ Hours/घण्टे **Full Marks/पूर्णांक :** 450

Note/नोट : (1) Attempt as many questions as you can. Each question carries **3** marks. **One** mark will be deducted for each incorrect answer. Zero mark will be awarded for each unattempted question.

अधिकाधिक प्रश्नों को हल करने का प्रयत्न करें। प्रत्येक प्रश्न **3** अंक का है। प्रत्येक गलत उत्तर के लिए एक अंक काटा जाएगा। प्रत्येक अनुत्तरित प्रश्न का प्राप्तांक शून्य होगा।

(2) If more than one alternative answers seem to be approximate to the correct answer, choose the closest one.

यदि एकाधिक वैकल्पिक उत्तर सही उत्तर के निकट प्रतीत हों, तो निकटतम सही उत्तर दें।

1. Let ΔW denote the work done during an infinitesimal quasi static reversible thermodynamic process. ΔW is

(1) not a perfect differential for any process

(2) a perfect differential only for an adiabatic process

(3) a perfect differential for all processes

(4) a perfect for an isothermal process

2. A canonical ensemble provides a model for

(1) an equilibrium system with fixed volume and number of molecules and which exchanges energy with the outside world

(2) an equilibrium isolated system with fixed volume, number of molecules and energy

(3) an equilibrium system with fixed volume and which can exchange energy and matter with the surroundings

(4) a system at constant pressure

3. n_k denotes the number of Fermions in quantum state k of energy ε_k. Let $\xi = \langle n_k \rangle$ be the average of number of Fermions in state k at temperature T and chemical potential μ. Let $\sigma^2 = \langle n_k^2 \rangle - \langle n_k \rangle^2$ be the variance of n_k. The relative fluctuation of the number of Fermions in state k, given by $\frac{\sigma}{\xi}$ is

(1) $\sqrt{\frac{1}{\xi}+1}$ (2) $\sqrt{\frac{1}{\xi}-1}$ (3) $\frac{1}{\xi}$ (4) $\frac{1}{\sqrt{\xi}}$

4. Assume that the heat capacity at constant volume of a metal varies as $aT + bT^3$ at low temperatures. The temperature dependence of entropy is given by

(1) $aT + bT^3$ (2) $a + bT^2$ (3) $aT + \frac{b}{3}T^3$ (4) $aT^2 + bT^4$

5. When temperature decreases the chemical potential of a system of Bosons

(1) increases and eventually goes to zero

(2) decreases and eventually goes to zero

(3) increases and becomes negative

(4) decreases and becomes negative

6. A card is drawn from a pack containing 52 cards with 4 aces and another card is drawn from a pack of 48 cards with 8 aces. What is the probability that both are aces?

(1) $\frac{4}{52}$ (2) $\frac{8}{48}$ (3) $\frac{32}{52\times 48}$ (4) $\frac{1}{78}$

7. In a coded telegram, the letters are arranged in groups of 5 letters called 'words'. How many different such words are there which contain each letter at most once?

(1) $\frac{26!}{(26-5)!}$ (2) $\frac{26!}{5!}$ (3) $\frac{26!}{5!(26-5)!}$ (4) $(26-5)!$

8. In a Maxwell-Boltzmann system with two states of energies ε and 2ε, respectively, and a degeneracy of 2 for each state, the partition function is

(1) $2e^{-2\varepsilon/kT}$

(2) $2e^{-3\varepsilon/kT}$

(3) $e^{-\varepsilon/kT}+e^{-2\varepsilon/kT}$

(4) $2[e^{-\varepsilon/kT}+e^{-2\varepsilon/kT}]$

9. An ensemble of systems is in thermal equilibrium with a reservoir for which $kT = 0 \cdot 025$ eV. State A has an energy that is $0 \cdot 1$ eV above that of state B. If it is assumed the systems obey Maxwell-Boltzmann statistics and that the degeneracies of the two states are the same, then the ratio of the number of systems in state A to the number in state B is

(1) $e^{+0 \cdot 25}$ (2) 1 (3) $e^{-0 \cdot 25}$ (4) e^{-4}

10. For a system in which the number of particles is fixed, the reciprocal of the Kelvin temperature T is given by which of the following derivatives? (Let P = pressure, V = volume, S = entropy and U = internal energy)

(1) $\left(\frac{\partial P}{\partial S}\right)_V$ (2) $\left(\frac{\partial S}{\partial P}\right)_U$ (3) $\left(\frac{\partial V}{\partial P}\right)_U$ (4) $\left(\frac{\partial S}{\partial U}\right)_V$

11. The length of a spaceship is measured to be exactly half of its proper length by an observer. The relative velocity of the observer is

(1) $\frac{1}{2}c$ (2) $\frac{\sqrt{2}}{3}c$ (3) $\frac{\sqrt{3}}{2}c$ (4) $\frac{1}{\sqrt{2}}c$

12. If the total energy of a particle of mass m is equal to twice its rest energy, then the magnitude of the particle's relativistic mechanism is

(1) $\frac{mc}{2}$ (2) $\frac{mc}{\sqrt{2}}$ (3) mc (4) $\sqrt{3}\,mc$

13. If a charged pion that decays in 10^{-8} second in its own rest frame is to travel 30 metres in the laboratory before decaying, the pion's speed must be most nearly

(1) $0{\cdot}43\times10^{8}$ m/s (2) $2{\cdot}84\times10^{8}$ m/s

(3) $2{\cdot}90\times10^{8}$ m/s (4) $2{\cdot}98\times10^{8}$ m/s

14. A particle leaving a cyclotron has a total relativistic energy of 10 GeV and a relativistic momentum of 9 GeV/c. What is the rest mass of this particle?

(1) 0·25 GeV/c^2 (2) 1·20 GeV/c^2 (3) 2·00 GeV/c^2 (4) 6·00 GeV/c^2

15. A tube of water is travelling at $\frac{1}{2c}$ relative to the lab frame when a beam of light travelling in the same direction as the tube enters it. What is the speed of light in the water relative to the lab frame? (The index of refraction of water is $\frac{4}{3}$.)

(1) $\frac{1}{2c}$ (2) $\frac{2}{3c}$ (3) $\frac{5}{6c}$ (4) $\frac{10}{11c}$

16. A photon strikes an electron of mass m that is initially at rest, creating an electron-positron pair. The photon is destroyed and the positron and two electrons move off at equal speeds along the initial direction of the photon. The energy of the photon was

(1) mc^2 (2) $2\,mc^2$ (3) $3\,mc^2$ (4) $4\,mc^2$

17. A positive kaon (K^+) has a rest mass of 494 MeV/c^2, whereas a proton has a rest mass of 938 MeV/c^2. If a kaon has a total energy that is equal to the proton rest energy, the speed of the kaon is most nearly

(1) $0{\cdot}40c$ (2) $0{\cdot}55c$ (3) $0{\cdot}70c$ (4) $0{\cdot}85c$

18. If a newly discovered particle X moves with a speed equal to the speed of light in vacuum, then which of the following must be true?

(1) The rest mass of X is zero

(2) The spin of X equals the spin of a photon

(3) The charge of X is carried on its surface

(4) X does not spin

19. In the limit $x \to \infty$, $\ln(x) - x$

(1) equals zero (2) equals 2 (3) equals $-\infty$ (4) equals 1

20. A matrix $C = \begin{pmatrix} 5 & -1 \\ 1 & 3 \end{pmatrix}$ has

(1) no independent eigenvectors (2) 1 independent eigenvector

(3) 2 independent eigenvectors (4) 3 independent eigenvectors

21. If for a scalar function ϕ, $\vec{\nabla}\phi = \frac{\vec{r}}{r^2}$, then ϕ is equal to

(1) $\frac{1}{r}$ (2) $\frac{1}{r^2}$ (3) $\ln(|r|)$ (4) $\ln(r)$

22. If $[x]$ stands for largest integer not exceeding x, then the integral

$$\int_{-1}^{+2} [x]\,dx$$

equals

(1) 3 (2) 0 (3) 1 (4) 2

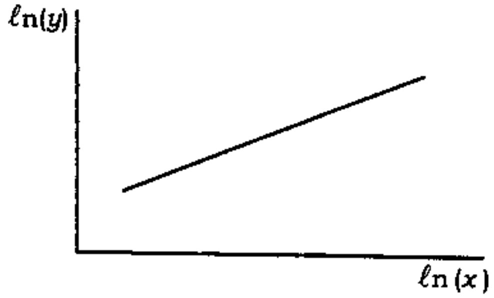
23. The eigenvalues of the matrix

$$\begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}$$

are

(1) 1, 0 (2) 1, 1 (3) 1, 2 (4) 0, 2

24. Which of the following equations is best represented by the graph below?



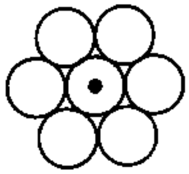
(1) $xy = a$, where a is a constant

(2) $y = mx + c$, where m and c are constants

(3) $y = \exp(x) + a$, where a is a constant

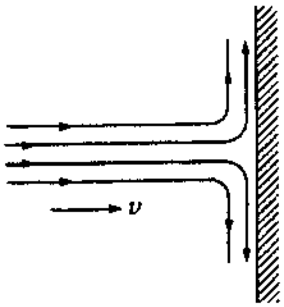
(4) $y = ax^m$, where a and m are constants

25. Seven pennies are arranged in a hexagonal, planar pattern so as to touch each neighbour, as shown in the figure below. Each penny is a uniform disk of mass m and radius r. What is the moment of inertia of the system of seven pennies about an axis that passes through the center of the central penny and is normal to the plane of the pennies?



(1) $\left(\frac{13}{2}\right) mr^2$ (2) $\left(\frac{29}{2}\right) mr^2$ (3) $\left(\frac{49}{2}\right) mr^2$ (4) $\left(\frac{55}{2}\right) mr^2$

26. A stream of water of density ρ, cross-sectional area A, and speed v strikes a wall that is perpendicular to the direction of the stream, as shown in the figure below. The water then flows sideways across the wall. The force exerted by the stream on the wall is



(1) $\rho v^2 A$ (2) $\rho v A/2$ (3) $\rho g h A$ (4) $v^2 A/\rho$

27. The Lagrangian for a mechanical system is $L = a\dot{q}^2 + bq^4$, where q is a generalized coordinate and a and b are constants. The equation of motion for this system is

(1) $\dot{q} = \sqrt{\frac{b}{a}}\, q^2$ (2) $\dot{q} = \frac{2b}{a} q^3$ (3) $\ddot{q} = -\frac{2b}{a} q^3$ (4) $\ddot{q} = +\frac{2b}{a} q^3$

28. The potential energy of a body constrained to move on a straight line is kx^4, where k is a constant. The position of the body is x, its speed v, its linear momentum p, and its mass m. The Hamiltonian function for this system is

(1) $\frac{p^2}{2m} + kx^4$ (2) $\frac{p^2}{2m} - kx^4$ (3) kx^4 (4) $\frac{1}{2}mv^2 - kx^4$

29. Five negative electric charges of magnitude e are placed symmetrically on a circle of radius R. The magnitude of the electric field at the center of the circle is

(1) $\frac{e}{4\pi\varepsilon_0 R^2}$ (2) 0

(3) $\frac{e}{4\pi\varepsilon_0 R^2} \sin\frac{2\pi}{5}$ (4) $\frac{5e}{4\pi\varepsilon_0 R^2}$

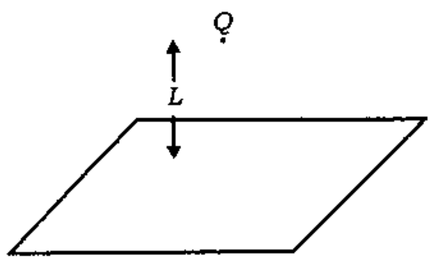
30. The mutual potential energy V of two particles depends on their spatial separation as follows

$$V = \frac{a}{r^2} - \frac{b}{r}; \quad a>0; \ b>0$$

For what separation are the particles in static equilibrium?

(1) $\frac{a}{b}$ (2) $\frac{a}{2b}$ (3) $\frac{a^2}{b}$ (4) $\frac{2a}{b}$

31. A positive charge Q is located at a distance L above an infinite grounded conducting plane, as shown in the figure below. What is the total charge induced on the plane?

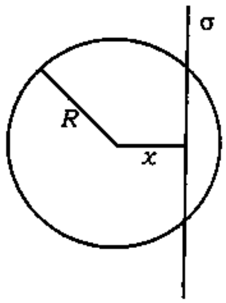


(1) $2Q$ (2) Q (3) 0 (4) $-Q$

32. A 3-microfarad capacitor is connected in series with a 6-microfarad capacitor. When a 300-volt potential difference is applied across this combination, the total energy stored in the two capacitors is

(1) 0·09 J (2) 0·18 J (3) 0·27 J (4) 0·41 J

33. An infinite, uniformly charged sheet with surface-charge density σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure below. The electric flux Φ through the Gaussian surface is

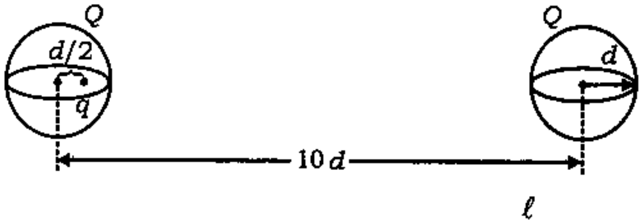


(1) $\frac{\pi R^2 \sigma}{\varepsilon_0}$ (2) $\frac{2\pi R^2 \sigma}{\varepsilon_0}$ (3) $\frac{\pi (R-x)^2 \sigma}{\varepsilon_0}$ (4) $\frac{\pi (R^2-x^2) \sigma}{\varepsilon_0}$

34. One end of a Nichrome wire of length $2L$ and cross-sectional area A is attached to an end of another Nichrome wire of length L and cross-sectional area $2A$. If the free end of the longer wire is at an electric potential of 8·0 volts and the free end of the shorter wire is at an electric potential of 1·0 volt, the potential at the junction of the two wires is most nearly equal to

(1) 2·4 V (2) 3·3 V (3) 4·5 V (4) 5·7 V

35. Two spherical, nonconducting and very thin shells of uniformly distributed positive charge Q and radius d are located a distance 10d from each other. A positive point charge q is placed inside one of the shells at a distance $d/2$ from the center, on the line connecting the centers of the two shells, as shown in the figure below. What is the net force on the charge q?



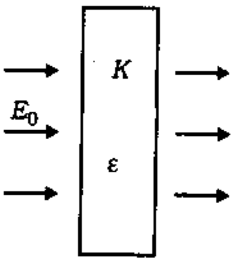
(1) $\dfrac{qQ}{361\pi\varepsilon_0 d^2}$ to the left

(2) $\dfrac{qQ}{361\pi\varepsilon_0 d^2}$ to the right

(3) $\dfrac{qQ}{441\pi\varepsilon_0 d^2}$ to the left

(4) $\dfrac{qQ}{441\pi\varepsilon_0 d^2}$ to the right

36. An infinite slab of insulating material with dielectric constant K and permittivity $\varepsilon = K\varepsilon_0$ is placed at a uniform electric field of magnitude E_0. The field is perpendicular to the surface of the material, as shown in the figure below. The magnitude of the electric field inside the material is



(1) $\dfrac{E_0}{K}$

(2) $\dfrac{E_0}{K\varepsilon_0}$

(3) E_0

(4) $K\varepsilon_0 E_0$

37. A uniformly charged sphere of total charge Q expands and contracts between radii R_1 and R_2 at a frequency f. The total power radiated by the sphere is

(1) proportional to f^2 (2) proportional to f^4

(3) proportional to (R_2/R_1) (4) zero

38. For blue light, a transparent material has a relative permittivity (dielectric constant) of 2·1 and a relative permeability of 1·0. If the speed of light in a vacuum is c, the phase velocity of blue light in an unbounded medium of this material is

(1) $\sqrt{3\cdot 1}\,c$ (2) $\sqrt{2\cdot 1}\,c$ (3) $\frac{c}{\sqrt{1\cdot 1}}$ (4) $\frac{c}{\sqrt{2\cdot 1}}$

39. A cube has a constant electric potential V on its surface. If there are no charges inside the cube, the potential at the center of the cube is

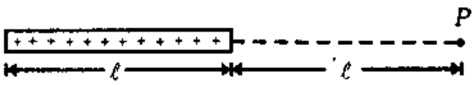
(1) zero (2) $V/8$ (3) $V/2$ (4) V

40. Which of the following electric fields could exist in a finite region of space that contains no charges? (In these expressions, A is a constant, and $\mathbf{i}$, $\mathbf{j}$ and $\mathbf{k}$ are unit vectors pointing in the x, y and z directions, respectively.)

(1) $A(2xy\,\mathbf{i} - xz\,\mathbf{k})$ (2) $A(-xy\,\mathbf{j} + xz\,\mathbf{k})$

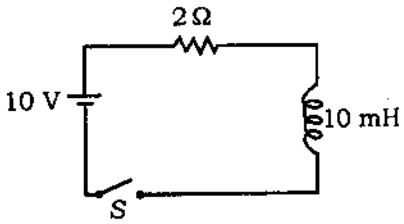
(3) $A(xz\,\mathbf{i} + xz\,\mathbf{j})$ (4) $Axyz(\mathbf{i} + \mathbf{j})$

41. The long thin cylindrical glass rod shown below has length l and is insulated from its surroundings. The rod has an excess charge Q uniformly distributed along its length. Assume the electric potential to be zero at infinite distances from the rod. If k is the constant in Coulomb's law, the electric potential at a point P along the axis of the rod and a distance l from one end is $\frac{kQ}{l}$ multiplied by

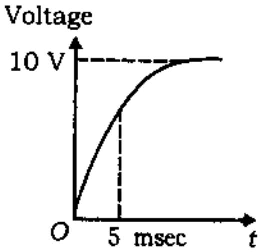


(1) $\frac{4}{9}$ (2) $\frac{1}{2}$ (3) $\frac{2}{3}$ (4) $\ln 2$

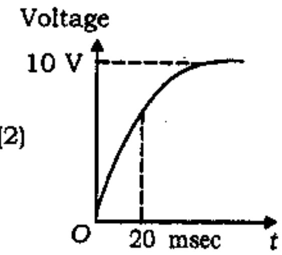
42. In the circuit shown in the figure below, the switch S is closed at $t = 0$. Which of the following best represents the voltage across the inductor, as seen on an oscilloscope?



(1)



(2)



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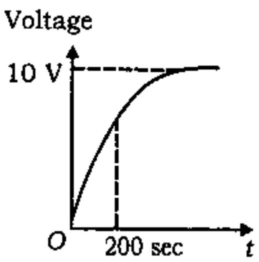
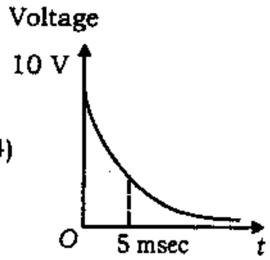


(4)



43. The field of magnetic vector $\vec{B}$ is always

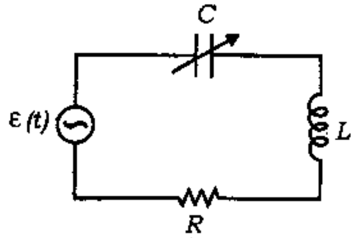
(1) irrotational

(2) solenoidal

(3) non-solenoidal

(4) both irrotational and non-solenoidal

44. An AC circuit consists of the elements shown in the figure below, with $R = 10000$ ohms, $L = 25$ millihenries, and C an adjustable capacitance. The AC voltage generator supplies a signal with an amplitude of 40 volts and angular frequency of 1000 radians per second. For what value of C is the amplitude of the current maximized?



(1) 4 nF (2) 40 nF (3) 4 μF (4) 40 μF

45. Maxwell's equations can be written in the form shown below. If magnetic charge exists and if it is conserved, which of these equations will have to be changed?

(A) $\nabla \cdot \mathbf{E} = \rho / \varepsilon_0$

(B) $\nabla \cdot \mathbf{B} = 0$

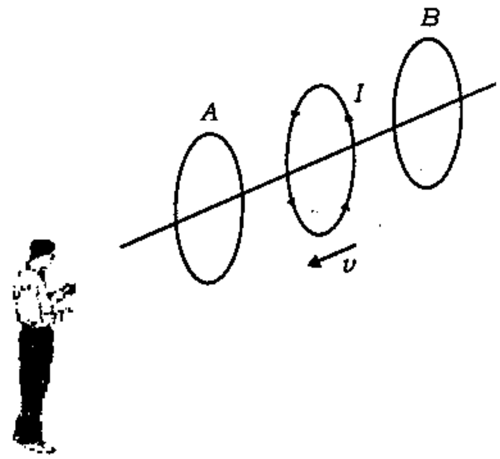
(C) $\nabla \times \mathbf{E} = -\dfrac{\partial \mathbf{B}}{\partial t}$

(D) $\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \varepsilon_0 \dfrac{\partial \mathbf{E}}{\partial t}$

(1) B only (2) C only

(3) A and D (4) B and C

46. Three wire loops and an observer are positioned as shown in the figure below. From the observer's point of view, a current I flows counterclockwise in the middle loop, which is moving towards the observer with a velocity v. Loops A and B are stationary. This same observer would notice that



(1) clockwise currents are induced in loops A and B

(2) counterclockwise currents are induced in loops A and B

(3) a clockwise current is induced in loop A, but a counterclockwise current is induced in loop B

(4) a counterclockwise current is induced in loop A, but a clockwise current is induced in loop B

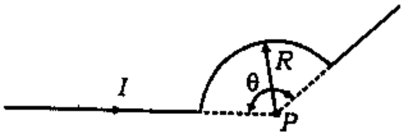
47. For an inductor and capacitor connected in series, the equation describing the motion of charge is

$$L\frac{d^2Q}{dt^2}+\frac{1}{C}Q=0$$

where L is the inductance. C is the capacitance, and Q is the charge. An analogous equation can be written for a simple harmonic oscillator with position x, mass m, and spring constant k. Which of the following correctly lists the mechanical analogs of L, C and Q ?

	L	C	Q		L	C	Q
(1)	m	k	x	(2)	m	$1/k$	x
(3)	k	x	m	(4)	$1/k$	$1/m$	x

48. A segment of wire is bent into an arc of radius R and subtended angle θ, as shown in the figure below. Point P is at the center of the circular segment. The wire carries current I. What is the magnitude of the magnetic field at P ?



(1) 0 (2) $\dfrac{\mu_0 I\theta}{(2\pi)^2 R}$ (3) $\dfrac{\mu_0 I\theta}{4\pi R}$ (4) $\dfrac{\mu_0 I\theta}{4\pi R^2}$

49. Which of the following equations is a consequence of the equation $\nabla\times\mathbf{H}=\dot{\mathbf{D}}+\mathbf{J}$?

(1) $\nabla\cdot(\dot{\mathbf{D}}+\mathbf{J})=0$ (2) $\nabla\times(\dot{\mathbf{D}}+\mathbf{J})=0$ (3) $\nabla(\dot{\mathbf{D}}\cdot\mathbf{J})=0$ (4) $\dot{\mathbf{D}}+\mathbf{J}=0$

50. A charged particle is released from rest in a region, where there is a constant electric field and a constant magnetic field. If the two fields are parallel to each other, the path of the particle is a

(1) parabola (2) helix (3) cycloid (4) straight line

51. A negative test charge is moving near a long straight wire in which there is a current. A force will act on the test charge in a direction parallel to the direction of the current if the motion of the charge is in a direction

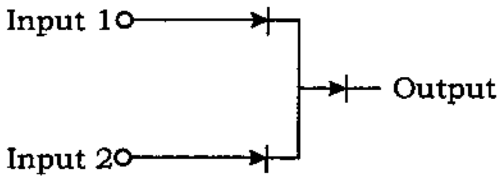
(1) toward the wire

(2) away from the wire

(3) the same as that of the current

(4) opposite to that of the current

52. If logical 0 is 0 volt and logical 1 is +1 volt, the circuit shown below is a logic circuit commonly known as



(1) an OR gate (2) an AND gate (3) a 2-bit adder (4) a flip-flop

53. What is the state of polarization of a plane electromagnetic wave when the x and y components of the electric field are given by

(A) $E_x = \frac{E_0}{2}\cos(\omega t - kz)$

$E_y = \frac{\sqrt{3}}{2} E_0 \sin(\omega t - kz)$

(B) $E_y = E_0 \cos(\omega t - kz)$

$E_x = -E_0 \sin(\omega t - kz)$

(1) (A) left elliptically polarized (B) linearly polarized

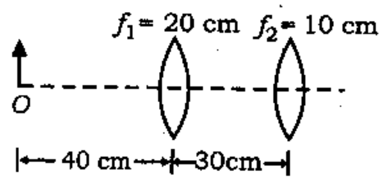
(2) (A) right elliptically polarized (B) left circularly polarized

(3) (A) left elliptically polarized (B) left circularly polarized

(4) (A) right circularly polarized (B) linearly polarized

54. An object is located 40 cm from the first of two thin converging lenses of focal lengths 20 cm and 10 cm respectively, as shown in the figure below. The lenses are separated by 30 cm. The final image formed by the two-lens system is located

54.



(1) 5·0 cm to the right of the second lens
(2) 13·3 cm to the right of the second lens
(3) infinitely far to the right of the second lens
(4) 13·3 cm to the left of the second lens

55. Two stars are separated by an angle of 3×10^{-5} radians. What is the diameter of the smallest telescope that can resolve the two stars using visible light ($\lambda \cong 600$ nanometres)? (Ignore any effects due to earth's atmosphere.)

(1) 1 mm (2) 2·5 cm (3) 10 cm (4) 2·5 m

56. Unpolarized light of intensity I_0 is incident on a series of three polarizing filters. The axis of the second filter is oriented at 45° to that of the first filter, while the axis of the third filter is oriented at 90° to that of the first filter. What is the intensity of the light transmitted through the third filter?

(1) 0 (2) $\frac{I_0}{8}$ (3) $\frac{I_0}{4}$ (4) $\frac{I_0}{2}$

57. Blue light of wavelength 480 nanometres is most strongly reflected off a thin film of oil on a glass side when viewed near normal incidence. Assuming that the index of refraction of the oil is 1·2 and that of the glass is 1·6, what is the minimum thickness of the oil film (other than zero)?

(1) 150 nm (2) 200 nm (3) 300 nm (4) 400 nm

58. Light from a Laser falls on a pair of very narrow slits separated by 0·5 micrometre and bright fringes separated by 1·0 millimetre are observed on a distant screen. If the frequency of the Laser light is doubled, what will be the separation of the bright fringes?

(1) 0·25 mm (2) 0·5 mm (3) 1·0 mm (4) 2·0 mm

59. Two coherent sources of visible monochromatic light form an interference pattern on a screen. If the relative phase of the sources is varied from 0 to 2π at a frequency of 500 Hz, which of the following best describes the effect, if any, on the interference pattern?

(1) It is unaffected because the frequency of the phase change is an integral multiple of π

(2) It is destroyed except when the phase difference is 0 or π

(3) It is destroyed for all phase differences because the monochromaticity of the sources is destroyed

(4) It is not destroyed but simply shifts positions at a rate too rapid to be detected by the eye

60. It is necessary to coat a glass lens with a non-reflecting layer. If the wavelength of the light in the coating is λ, the best choice is a layer of material having an index of refraction between those of glass and air and a thickness of

(1) $\frac{\lambda}{4}$ (2) $\frac{\lambda}{2}$ (3) $\frac{\lambda}{\sqrt{2}}$ (4) λ

61. The screen of a pinhole camera is at a distance D from the pinhole, which has a diameter d. The light has an effective wavelength λ ($\lambda << D$). For which of the following values of d will the image be sharpest?

(1) $\sqrt{\lambda D}$ (2) λ (3) $\frac{\lambda}{10}$ (4) $\frac{\lambda^2}{D}$

62. A particle is confined in a one-dimensional box of length l. Its wave function is given by

$$\psi(x) = \begin{cases} \sqrt{\frac{2}{l}} \sin\left(\frac{\pi x}{l}\right) & \text{for } 0 < x < l \\ 0 & \text{for } l < x < 0 \end{cases}$$

The expectation values of the x-component of momentum is

(1) 1 (2) 0·5 (3) $\frac{l}{2}$ (4) zero

63. The eigenvalues of a Hermitian operator are always

(1) real (2) imaginary (3) degenerate (4) linear

64. The state

$$\psi = \frac{1}{\sqrt{6}}\psi_{-1} + \frac{1}{\sqrt{2}}\psi_1 + \frac{1}{\sqrt{3}}\psi_2$$

is a linear combination of three orthonormal eigenstates of the operator $\hat{O}$ corresponding to eigenvalues -1, 1 and 2. What is the expectation value of $\hat{O}$ for this state?

(1) $\frac{2}{3}$ (2) $\sqrt{\frac{7}{6}}$ (3) 1 (4) $\frac{4}{3}$

65. Which of the following functions could represent the radial wave function for an electron in an atom? (r is the distance of the electron from the nucleus, A and b are constants.)

(A) $A\,e^{-br}$

(B) $A\sin(br)$

(C) A/r

(1) A only (2) B only (3) A and B only (4) A and C only

66. Let $|n\rangle$ represent the normalized nth energy eigenstate of the one-dimensional harmonic oscillator

$$H|n\rangle = \hbar\omega\left(n+\frac{1}{2}\right)|n\rangle$$

If $|\psi\rangle$ is a normalized ensemble state that can be expanded as a linear combination

$$|\psi\rangle = \frac{1}{\sqrt{14}}|1\rangle - \frac{2}{\sqrt{14}}|2\rangle + \frac{3}{\sqrt{14}}|3\rangle$$

of the eigenstates, what is the expectation value of the energy operator in this ensemble state?

(1) $\frac{102}{14}\hbar\omega$ (2) $\frac{43}{14}\hbar\omega$ (3) $\frac{23}{14}\hbar\omega$ (4) $\frac{17}{\sqrt{14}}\hbar\omega$

67. A free particle with initial kinetic energy E and de Broglie wavelength λ enters a region in which it has potential energy V. What is the particle's new de Broglie wavelength?

(1) $\lambda(1-V/E)$

(2) $\lambda(1-E/V)^{-1}$

(3) $\lambda(1+V/E)^{1/2}$

(4) $\lambda(1-V/E)^{-1/2}$

68. The wave function

$$\psi(x) = A \exp\left\{-\frac{b^2 x^2}{2}\right\}$$

where A and b are real constants, is a normalized eigenfunction of the Schrödinger equation for a particle of mass M and energy E in a one-dimensional potential $V(x)$ such that $V(x)=0$ at $x=0$. Which of the following is correct?

(1) $V = \frac{\hbar^2 b^4}{2M}$

(2) $V = \frac{\hbar^2 b^4 x^2}{2M}$

(3) $V = \frac{\hbar^2 b^6 x^4}{2M}$

(4) $E = \hbar^2 b^2 (1 - b^2 x^2)$

69. Eigenfunctions for a rigid dumbbell rotating about its center have a ϕ dependence of the form $\psi(\phi) = Ae^{im\phi}$, where m is a quantum number and A is a constant. Which of the following values of A will properly normalize the eigenfunction?

(1) $\sqrt{2\pi}$

(2) 2π

(3) $(2\pi)^2$

(4) $\frac{1}{\sqrt{2\pi}}$

70. The Franck-Hertz experiment and related scattering experiments show that

(1) electrons are always scattered elastically from atoms

(2) electrons are never scattered elastically from atoms

(3) electrons of a certain energy range can be scattered inelastically, and the energy lost by electrons is discrete

(4) electrons always lose the same energy when they are scattered inelastically

71. If ψ is a normalized solution of the Schrödinger equation and Q is the operator corresponding to a physical observable x, the quantity $\psi^* Q \psi$ may be integrated in order to obtain the

(1) normalization constant for ψ

(2) spatial overlap of Q with ψ

(3) mean value of x

(4) uncertainty in x

72. Which of the following is an eigenfunction of the linear momentum operator $-i\hbar\frac{\partial}{\partial x}$ with a positive eigenvalue $\hbar k$, i.e., an eigenfunction that describes a particle that is moving in free space in the direction of positive x with a precise value of linear momentum?

(1) $\cos kx$ (2) $\sin kx$ (3) e^{-ikx} (4) e^{ikx}

73. The dispersion law for a certain type of wave motion is $\omega = (c^2k^2 + m^2)^{1/2}$, where ω is the angular frequency, k is the magnitude of the propagation vector and c and m are constants. The group velocity of these waves approaches

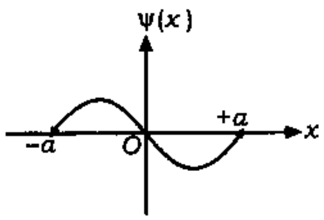
(1) infinity as $k \to 0$ and c as $k \to \infty$

(2) c as $k \to 0$ and zero as $k \to \infty$

(3) zero as $k \to 0$ and infinity as $k \to \infty$

(4) zero as $k \to 0$ and c as $k \to \infty$

74. In the figure below shows one of the possible energy eigenfunctions $\psi(x)$ for a particle bouncing freely back and forth along the x-axis between impenetrable walls located at $x = -a$ and $x = +a$. The potential energy equals zero for $|x| < a$. If the energy of the particle is 2 electron volts when it is in the quantum state associated with this eigenfunction, what is its energy when it is in the quantum state of lowest possible energy?



(1) 0 eV (2) $\frac{1}{\sqrt{2}}$ eV (3) $\frac{1}{2}$ eV (4) 1 eV

75. Which one of the following operators is Hermitian?

(1) e^{ix} (2) xp_y (3) $\frac{\partial}{\partial x}$ (4) $\frac{i\partial}{\partial x}$

76. The ground state electron configuration for phosphorus, which has 15 electrons, is

(1) $1s^2 2s^2 2p^6 3s^1 3p^4$ (2) $1s^2 2s^2 2p^6 3s^2 3p^3$

(3) $1s^2 2s^2 2p^6 3s^2 3d^3$ (4) $1s^2 2s^2 2p^6 3s^1 3d^4$

77. The energy required to remove both electrons from the helium atom in its ground state is 79·0 eV. How much energy is required to ionize helium (i.e., to remove one electron)?

(1) 24·6 eV (2) 39·5 eV (3) 51·8 eV (4) 54·4 eV

78. In the hydrogen spectrum, the ratio of the wavelengths for Lyman-α radiation ($n=2$ to $n=1$) to Balmer-α radiation ($n=3$ to $n=2$) is

(1) $\frac{5}{48}$ (2) $\frac{5}{27}$ (3) $\frac{1}{3}$ (4) 3

79. The configuration of the potassium atom in its ground state is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$. Which of the following statements about potassium is true?

(1) Its $4s$ subshell is completely filled

(2) Its least tightly bound electron has $l=4$

(3) Its atomic number is 17

(4) Its electron charge distribution is spherically symmetrical

80. A spectral line is produced by a gas that is sufficiently dense that the mean time between atomic collisions is much shorter than the mean lives of the atomic states responsible for the line. Compared with the same line produced by a low-density gas, the line produced by the higher-density gas will appear

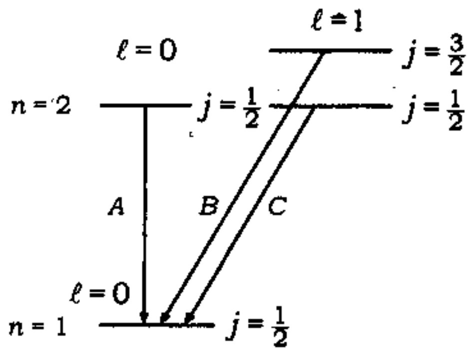
(1) the same

(2) more highly polarized

(3) broader

(4) shifted toward the blue end of the spectrum

81. An energy-level diagram of the $n = 1$ and $n = 2$ levels of atomic hydrogen (including the effects of spin-orbit coupling and relativity) is shown in the figure below. Three transitions are labelled A, B and C. Which of the transitions will be possible electric-dipole transitions?



(1) B only (2) C only (3) A and C only (4) B and C only

82. The positronium 'atom' consists of an electron and a positron bound together by their mutual Coulomb attraction and moving about their center of mass, which is located halfway between them. Thus the positronium 'atom' is somewhat analogous to a hydrogen atom. The ground-state binding energy of hydrogen is 13·6 electron volts. What is the ground-state binding energy of positronium?

(1) $\left(\frac{1}{2}\right)^2 \times 13{\cdot}6$ eV

(2) $\frac{1}{2} \times 13{\cdot}6$ eV

(3) 13·6 eV

(4) $2 \times 13{\cdot}6$ eV

83. The energy levels of the hydrogen atom are given in terms of the principal quantum number n and a positive constant A by the expression

(1) $A(1-n^2)$ (2) $A\left(-\frac{1}{4}+\frac{1}{n^2}\right)$ (3) An^2 (4) $-\frac{A}{n^2}$

84. The hypothesis that an electron possesses spin is qualitatively significant for the explanation of all of the following topics, *except* the

(1) structure of the periodic table

(2) specific heat of metals

(3) anomalous Zeeman effect

(4) deflection of a moving electron by a uniform magnetic field

85. The emission spectrum of an atomic gas in a magnetic field differs from that of the gas in the absence of a magnetic field. Which of the following is true of the phenomenon?

(1) It is called the Stark effect

(2) It is due primarily to the nuclear magnetic moment of the atoms

(3) The number of emission lines observed for the gas in a magnetic field is always twice the number observed in the absence of a magnetic field.

(4) The number of emission lines observed for the gas in a magnetic field is either greater than or equal to the number observed in the absence of a magnetic field

86. In the beta decay process $n \rightarrow p + e^- + X$, X stands for

(1) neutron (2) photon (3) neutrino (4) antineutrino

87. A radioactive nucleus of type 1 decays exponentially with a decay constant λ_1 to stable nucleus of type 2. If at time $t = 0$, the numbers of type 1 and 2 nuclei are respectively $N_1 = N_0$ and $N_2 = 0$, what is the number of type 2 nucleus present at time t?

(1) $N_0 \exp - \lambda_1 t$

(2) $N_0 (1 - \exp - \lambda_1 t)$

(3) $N_0 (1 + \exp - \lambda_1 t)$

(4) $1 - N_0 \exp - \lambda_1 t$

88. The binding energy per nucleon of a nucleus

(1) increases continuously with mas number

(2) decreases continuously with mas number

(3) remains constant with mas number

(4) first increases and then decreases with mass number

89. If there are N radioactive atoms in a given sample with a half-life of 10 years, then

(1) all the atoms would have decayed in 20 years

(2) $3N/4$ atoms would have decayed in 20 years

(3) $N/4$ atoms would have decayed in 20 years

(4) $\log(N/2)$ atoms would have decayed in 10 years

90. A sample of radioactive nuclei of a certain element can decay only by γ-emission and β-emission. If the half-life for γ-emission is 24 minutes and that for β-emission is 36 minutes, the half-life for the sample is

(1) 30 minutes (2) 24 minutes (3) 20·8 minutes (4) 14·4 minutes

91. The ^{238}U nucleus has a binding energy of about 7·6 MeV per nucleon. If the nucleus were to fission into two equal fragments, each would have a kinetic energy of just over 100 MeV. From this, it can be concluded that

(1) ^{238}U has a large neutron excess

(2) nuclei near $A = 120$ have masses greater than half that of ^{238}U

(3) nuclei near $A = 120$ must be bound by about 6·7 MeV/nucleon

(4) nuclei near $A = 120$ must be bound by about 8·5 MeV/nucleon

92. When $^{7}_{4}$Be transforms into $^{7}_{3}$Li, it does so by

(1) emitting an electron only

(2) emitting a neutron only

(3) emitting a positron only

(4) electron capture by the nucleus with emission of a neutrino

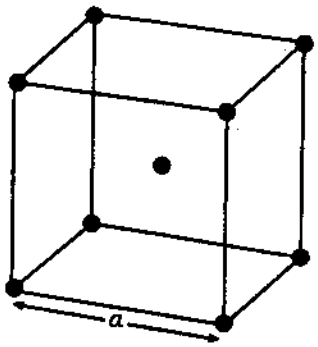
93. Suppose that $^{A}_{Z}X$ decays by natural radioactivity in two stages to $^{A-4}_{Z-1}Y$. The two stages would most likely be which of the following?

	First Stage	Second Stage
(1)	β^- emission with an antineutrino	α emission
(2)	β^- emission	α emission with a neutrino
(3)	β^- emission	γ emission
(4)	Emission of a deuteron	emission of two neutrons

94. An 8-centimetre diameter by 8-centimetre long NaI(Tl) detector detects gamma rays of a specific energy from a point source of radioactivity. When the source is placed just next to the detector at the center of the circular face, 50 percent of all emitted gamma rays at that energy are detected. If the detector is moved to 1 metre away, the fraction of detected gamma rays drops to

(1) 10^{-4} (2) 2×10^{-4} (3) 4×10^{-4} (4) $8\pi\times10^{-4}$

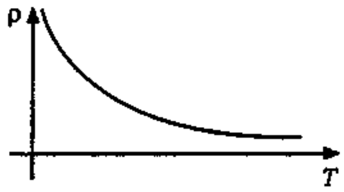
95. The conventional unit cell of a body-centered cubic Bravais lattice is shown in the figure below. The conventional cell has volume a^3. What is the volume of the primitive unit cell?

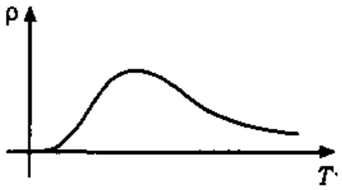


(1) $\frac{a^3}{8}$ (2) $\frac{a^3}{4}$ (3) $\frac{a^3}{2}$ (4) a^3

96. Which of the following best represents the temperature dependence of the resistivity of an undoped semiconductor?

(1)


(2)


(3)


(4)


97. The mean kinetic energy of the conduction electrons in metals is ordinarily much higher than kT because

(1) electrons have many more degrees of freedom than atoms do

(2) the electrons and the lattice are not in thermal equilibrium

(3) the electrons form a degenerate Fermi gas

(4) electrons in metals are highly relativistic

98. Which of the following statements concerning the electrical conductivities at room temperature of a pure copper sample and a pure silicon sample is NOT true?

(1) If the temperature of the copper sample is increased, its conductivity will decrease

(2) If the temperature of the silicon sample is increased, its conductivity will increase

(3) The addition of an impurity in the copper sample always decreases its conductivity

(4) The addition of an impurity in the silicon sample always decreases its conductivity

99. The Hall effect is used in solid-state physics to measure

(1) ratio of charge to mass

(2) magnetic susceptibility

(3) the sign of the charge carriers

(4) the width of the gap between the conduction and valence bands

100 Lattice forces affect the motion of electrons in a metallic crystal, so that the relationship between the energy E and wave number k is not the classical equation $E = \hbar^2 k^2 / 2m$, where m is the electron mass. Instead, it is possible to use an effective mass m^* given by which of the following?

(1) $m^* = \frac{1}{2}\hbar^2 k \left(\frac{dk}{dE}\right)$

(2) $m^* = \frac{\hbar^2 k}{\left(\frac{dk}{dE}\right)}$

(3) $m^* = \hbar^2 k \left(\frac{d^2 k}{dE^2}\right)^{\frac{1}{3}}$

(4) $m^* = \frac{\hbar^2}{\left(\frac{d^2 E}{dk^2}\right)}$

101. The longest wavelength X-ray that can undergo Bragg diffraction in a crystal for a given family of planes of spacing d is

(1) $\frac{d}{4}$ (2) $\frac{d}{2}$ (3) d (4) $2d$

102. For a spherical shell of radius R which carries a uniform surface charge

(1) both the field and the potential inside the shell are non-zero

(2) both the field and the potential inside the shell are zero

(3) the field inside the shell is non-zero while potential inside the shell is zero

(4) the field inside the shell is zero while potential inside the shell is non-zero

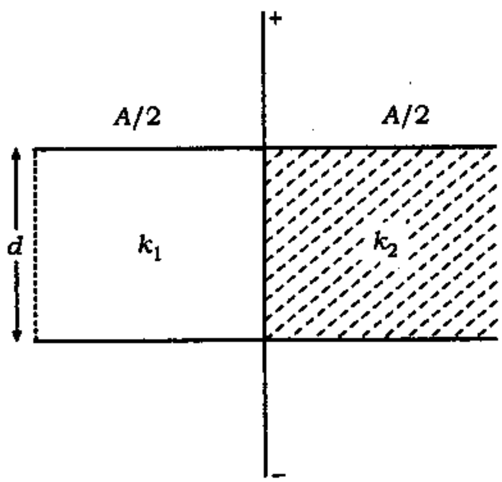
103. Consider a uniform spherical charge distribution with a total charge Q. The potential at the centre of the charge distribution is given by

(1) 0 (2) $\frac{Q}{(8\pi\varepsilon_0 a)}$ (3) $\frac{3Q}{(8\pi\varepsilon_0 a)}$ (4) $\frac{Q}{(4\pi\varepsilon_0 a^2)}$

104. A charge Q is placed at the centre of the line joining two equal charges Q. The system of three charges will be in equilibrium if q is equal to

(1) $-Q/2$ (2) $-Q/4$ (3) $Q/4$ (4) $Q/2$

105. A parallel plate capacitor is filled with two dielectrics as shown in the figure below. A is the area of a plate and d is the separation between the plates. The capacitance of the capacitor is



(1) $C = \frac{\varepsilon_0 A}{d}\left(\frac{k_1 + k_2}{2}\right)$

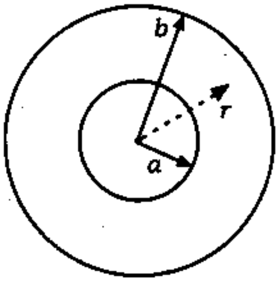
(2) $C = \frac{\varepsilon_0 A}{d}(k_1 - k_2)$

(3) $C = \frac{\varepsilon_0 A}{d}\left(\frac{k_1 - k_2}{2}\right)$

(4) $C = \frac{\varepsilon_0 A}{d}(k_1 + k_2)$

relative permittivity of the medium.)

106. A hollow spherical shell carries charge density $\rho = \frac{k}{r^2}$ in the region $a \le r \le b$. The electric field in the region $a < r < b$ is



(1) $E = \frac{k}{\varepsilon_0}\left(\frac{a-b}{r^2}\right)\hat{r}$

(2) $E = \frac{k}{\varepsilon_0}\left(\frac{r-a}{r^2}\right)\hat{r}$

(3) $E = \frac{k}{\varepsilon_0}\left(\frac{a}{r^2}\right)\hat{r}$

(4) $E = \frac{k}{\varepsilon_0}\left(\frac{b}{r^2}\right)\hat{r}$

107. If the electric flux through a closed surface S is equal to zero, then

(1) the volume charge density is zero everywhere inside the surface S

(2) the electric field at every point on S is zero

(3) the electric field is zero at every point inside S

(4) the net charge enclosed by S is zero

108. For a plane electromagnetic wave propagating in free space, which of the following relations between $\vec{E}$ and $\vec{B}$, the electric and magnetic fields at a given point in space, and the unit vector $\hat{k}$ in the direction of propagation, is not correct?

(1) $\vec{B} = \frac{1}{C}\hat{k} \times \vec{E}$

(2) $\vec{E} = \frac{1}{C}\vec{B} \times \hat{k}$

(3) $\vec{E} = C\vec{B} \times \hat{k}$

(4) $\hat{k} \cdot \vec{E} = 0$

109. A particle moves with a constant speed v in a magnetic field B. The work done is

(1) zero

(2) proportional to the velocity

(3) proportional to the magnetic field

(4) proportional to the charge q of the particle

110. For a CE transistor to function as an amplifier, it is necessary to keep

(1) E-B junction forward biased and C-E junction forward biased

(2) E-B junction reverse biased and C-E junction reverse biased

(3) E-B junction reverse biased and C-E junction forward biased

(4) E-B junction forward biased and C-E junction reverse biased

111. Zener diode can be used as

(1) an amplifier

(2) an oscillator

(3) a voltage regulator

(4) All of the above

112. Blue colour of the sky and redness of the setting sun can be explained by

(1) Rutherford scattering

(2) Rayleigh scattering

(3) emission from the atmospheric gases

(4) absorption of atmospheric gases

113. A diffraction grating 3 cm wide produces a deviation of 33 degrees in the second orde with light of wavelength 600 nm. What is the total number of lines on the grating?

(1) 3616 lines

(2) 136 lines

(3) 1124 lines

(4) 13616 lines

114. ν_1 is the frequency of the input current given to a full-wave rectifier, ν_2 is the frequency of the output current from the full-wave rectifier, then

(1) $\nu_1 = \nu_2$ (2) $\nu_1 = \nu_2 / 2$ (3) $\nu_1 = 2\nu_2$ (4) $\nu_1 = 4\nu_2$

115. Reduce $AB + ABC + \overline{A}B + A\overline{B}C$ using law's of Boolean algebra

(1) $B + AC$ (2) $A + BC$ (3) $C + AB$ (4) $A + B + C$

116. The uncertainty relation holds for the following situation

(1) holds for particles only

(2) does not hold for microscopic particles

(3) holds for both microscopic and macroscopic particles

(4) depends on the nature of the particle

117. According to wave mechanics, a free particle in space can possess energies of the following type

(1) Discrete energies (2) Continuous energies

(3) Both types of energies (4) Only one single value of energy

118. If the de Broglie wavelengths of an electron and proton are equal, then

(1) the velocity of proton is less than that of the electron

(2) the velocities of proton and electron are equal

(3) the velocity of proton is greater than that of the electron

(4) the energy of electron is less than that of the proton

119. Stern-Gerlach experiment shows that the electron

(1) has a negative charge

(2) carries a spin equal to $\frac{1}{2}$

(3) exhibits particle nature only

(4) exhibits wave-particle duality

120. The position and momentum of a 1 keV electron are simultaneously determined. If its position is located to within 1 Å, what is the percentage of uncertainty in its momentum?

(1) 0·61 (2) 6·17 (3) 61·73 (4) 0·061

121. A particle is moving in a one-dimensional potential box of infinite height. What is the probability of finding the particle in a small interval Δx at the centre of the box when it is in the energy state, next to the least energy state?

(1) 0 (2) 0·15 (3) 0·35 (4) 0·5

122. The photoelectric equation is derived under the assumption that

(1) electrons are associated with waves of wavelength $\lambda = \frac{h}{P}$, where P is the momentum

(2) light is emitted only when electrons jump between the orbits

(3) light is absorbed in quanta of energy $E = h\nu$

(4) light behaves like a wave

123. Photons of wavelength λ scatter elastically from free protons initially at rest. The wavelength of the photons scattered at 90° is increased by

(1) $\frac{\lambda}{137}$ (2) $\frac{h}{m_e C}$ (3) $\frac{h}{m_p C}$ (4) 0

where m_e and m_p are the rest mass of the electron and proton.

124. The number of electrons emitted increases if the incident light has

(1) higher frequency (2) higher wavelength

(3) higher intensity (4) lower frequency

125. The photoelectric threshold for a metal is 3000 Å. The kinetic energy of an electron ejected from it by radiation of wavelength 1200 Å is

(1) 3·1 eV (2) 12·6 eV (3) 6·2 eV (4) 21·4 eV

126. Wavelength of the photon emitted when the hydrogen atom goes from $n = 10$ state to the ground state is

(1) 921 Å (2) 0·921 Å (3) 9·21 Å (4) 92·1 Å

127. Which of the following nuclei has the largest binding energy per nucleon?

(1) ^{4}He (2) ^{56}Fe (3) ^{12}C (4) ^{238}U

128. The missing particle in the nuclear reaction

$$^{4}_{2}He + ^{14}_{7}N \rightarrow ^{17}_{8}O + ?$$

is a

(1) proton (2) neutron (3) electron (4) photon

129. According to semiempirical mass formula, surface energy correction to the atomic mass of a nucleus is proportional to

(1) $A^{1/3}$ (2) $A^{3/2}$ (3) $A^{1/2}$ (4) $A^{2/3}$

130. What is the amount of energy released when 10 micrograms of uranium (^{235}U) undergoes fission, if energy released per fission is 200 MeV?

(1) $5 \cdot 126 \times 10^{18}$ MeV (2) 5·126 MeV

(3) 5·125 MeV (4) $5 \cdot 126 \times 10^{6}$ MeV

131. The energy spectrum of a radioactive source emitting beta radiation is

(1) discrete

(2) continuous from zero to infinity

(3) continuous from zero to maximum cutoff energy

(4) partly continuous and partly discrete

132. The source of energy from the sun is mostly due to

(1) nuclear fission

(2) nuclear fusion

(3) the production of helium from hydrogen

(4) bremsstrahlung

133. 1 gram of a radioactive substance disintegrates at the rate of $3 \cdot 7 \times 10^{10}$ disintegrations per second. The atomic weight of the substance is 226. Its mean life is

(1) 22 years (2) 2282 years (3) 44 years (4) 4462 years

134. The isotope $_6C^{11}$ decays into $_5B^{11}$ The emitted particle is

(1) positron (2) electron (3) proton (4) neutron

135. A reactor is developing energy at the rate of 32×10^6 watts. How many atoms of ^{235}U undergo fission per second?

(Assume that on the average, an energy of 200 MeV is released per fission.)

(1) 10^6 (2) 10^{12} (3) 10^{18} (4) 10^{24}

136. If ${}_1H^2$ nuclei can fuse together to form ${}_2He^4$ nucleus, then the energy released is

(1) 13·6 MeV (2) 23·6 MeV (3) 236 MeV (4) 2·36 MeV

137. The half-life of radon is 3·8 days. After how many days will only $\frac{1}{20}$ of a radon sample be left over?

(1) 16·43 days (2) 164·3 days (3) 23·7 days (4) 237 days

138. The diffraction pattern of copper metal was measured with X-ray radiation of wavelength of 1·315 Å. The first order Bragg diffraction peak was found at an angle 2θ of 50·5°. The d-spacing between the diffracting planes in the copper metal is

(1) 3·25 Å (2) 1·54 Å (3) 0·41 Å (4) 4·2 Å

139. Packing fraction of an f.c.c. lattice is

(1) 0·52 (2) 0·32 (3) 0·74 (4) 0·62

140. In a simple cubic lattice $a=2$ Å, then planar atomic density of (1, 0, 0) plane is

(1) 10^{15} atoms/c.c. (2) $2\cdot5\times10^{15}$ atoms/c.c.

(3) 5×10^{15} atoms/c.c. (4) $7\cdot5\times10^{15}$ atoms/c.c.

141. The continuous X-ray spectrum is the result of the

(1) photoelectric effect
(2) inverse photoelectric effect
(3) Compton effect
(4) Auger effect

142. 10101 binary number corresponds to decimal number

(1) 31
(2) 21
(3) 11
(4) 3

143. The origin of van der Waals' interaction in molecular crystal is

(1) nuclear
(2) magnetic
(3) ionic
(4) fluctuating dipolar

144. The crystal structure of diamond is

(1) f.c.c. with two-atom basis of (0 0 0) and $\frac{a}{4}(\hat{i}+\hat{j}+\hat{k})$

(2) simple cubic with two-atom basis of (0 0 0) and $\frac{a}{2}(\hat{i}+\hat{j}+\hat{k})$

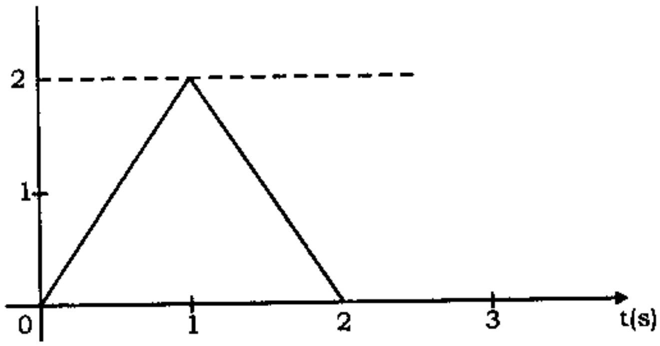
(3) f.c.c. with two-atom basis of (0 0 0) and $\frac{a}{2}(\hat{i}+\hat{j}+\hat{k})$

(4) b.c.c. with one-atom basis

145. In a non-relativistic one-dimensional collision, a particle of mass $2m$ collides with a particle of mass m at rest. If the particles stick together after the collision, what fraction of the initial kinetic energy is lost in the collision?

(1) 0
(2) $\frac{1}{4}$
(3) $\frac{1}{3}$
(4) $\frac{1}{2}$

146. In the figure below shows a plot of the time-dependent force $F_x(t)$ acting on a particle in motion along the x-axis. What is the total impulse delivered to the particle?



(1) 0 (2) 1 kg m/s (3) 2 kg m/s (4) 3 kg m/s

147. $\underset{x \to \infty}{\text{Lt}} \sqrt{x}\,(\sqrt{x+4} - \sqrt{x})$ is

(1) 0 (2) 2 (3) $\frac{1}{2}$ (4) Does not exist

148. Let f be a function of a real variable such that $f(\alpha+\beta) = f(\alpha) + f(\beta)$ for all α and β. Let m and n be integers. Then $f\left(\frac{m}{n}\right)$ equals

(1) $\frac{m}{n}$ (2) $\frac{f(m)}{f(n)}$ (3) $f(1) \times \frac{m}{n}$ (4) $f(m) + f\left(\frac{1}{n}\right)$

149. $a_1 = 1$ and $a_n = n\,(1 + a_{n-1})$ for $n = 2, 3$. Define

$$P_n = \prod_{k=1}^{n} \left(1 + \frac{1}{a_k}\right)$$

Then $\underset{n \to \infty}{\text{lt}} P_n$ is

(1) 1 (2) ∞ (3) e (4) $1+e$

150. The equation

$$y = A \sin 2\pi \left(\frac{t}{T} - \frac{x}{\lambda} \right)$$

where A, T and λ are positive constants, represents a wave whose

(1) amplitude is $2A$

(2) period is $\frac{T}{\lambda}$

(3) speed is $\frac{x}{t}$

(4) speed is $\frac{\lambda}{T}$

★★★

अभ्यर्थियों के लिए निर्देश

(इस **पुस्तिका के प्रथम** आवरण-**पृष्ठ** पर तथा उत्तर-पत्र के दोनों पृष्ठों पर केवल नीली या काली बाल-प्वाइंट पेन से ही लिखें)

1. प्रश्न पुस्तिका मिलने के 10 मिनट के अन्दर ही देख लें कि प्रश्नपत्र में सभी पृष्ठ मौजूद हैं और कोई प्रश्न छूटा नहीं है। पुस्तिका दोषयुक्त पाये जाने पर इसकी सूचना तत्काल कक्ष-निरीक्षक को देकर सम्पूर्ण प्रश्नपत्र की दूसरी पुस्तिका प्राप्त कर लें।

2. परीक्षा भवन में *लिफाफा रहित प्रवेश-पत्र के अतिरिक्त,* लिखा या सादा कोई भी खुला कागज साथ में न लायें।

3. उत्तर-पत्र अलग से दिया गया है। ***इसे न तो मोड़ें और न ही विकृत करें। दूसरा उत्तर-पत्र नहीं दिया जायेगा, केवल उत्तर-पत्र का ही मूल्यांकन किया जायेगा।***

4. अपना *अनुक्रमांक तथा उत्तर-पत्र का क्रमांक प्रथम आवरण-पृष्ठ पर पेन* से निर्धारित स्थान पर लिखें।

5. **उत्तर-पत्र के प्रथम पृष्ठ पर पेन से अपना अनुक्रमांक निर्धारित स्थान** पर लिखें तथा नीचे दिये वृत्तों को गाढ़ा कर दें। जहाँ-जहाँ आवश्यक हो वहाँ प्रश्न-पुस्तिका का क्रमांक तथा सेट का नम्बर उचित स्थानों पर लिखें।

6. ओ० एम० आर० पत्र पर अनुक्रमांक संख्या, प्रश्न-पुस्तिका संख्या व सेट संख्या (यदि कोई हो) तथा प्रश्न-पुस्तिका पर अनुक्रमांक सं० और ओ० एम० आर० पत्र सं० की प्रविष्टियों में उपरिलेखन की अनुमति नहीं है।

7. उपर्युक्त प्रविष्टियों में कोई भी परिवर्तन कक्ष निरीक्षक द्वारा प्रमाणित होना चाहिये अन्यथा यह एक अनुचित साधन का प्रयोग माना जायेगा।

8. प्रश्न-पुस्तिका में प्रत्येक प्रश्न के चार वैकल्पिक उत्तर दिये गये हैं। ***प्रत्येक प्रश्न के वैकल्पिक उत्तर के लिये आपको उत्तर-पत्र की सम्बन्धित पंक्ति के सामने दिये गये वृत्त को उत्तर-पत्र के प्रथम पृष्ठ पर दिये गये निर्देशों के अनुसार पेन से गाढ़ा करना है।***

9. प्रत्येक प्रश्न के उत्तर के लिये केवल एक ही वृत्त को गाढ़ा करें। एक से अधिक वृत्तों को गाढ़ा करने पर अथवा एक वृत्त को अपूर्ण भरने पर वह उत्तर गलत माना जायेगा।

10. ध्यान दें कि एक बार स्याही द्वारा अंकित उत्तर बदला नहीं जा सकता है। यदि आप किसी प्रश्न का *उत्तर नहीं देना चाहते हैं,* तो सम्बन्धित पंक्ति के सामने दिये गये सभी वृत्तों को खाली छोड़ दें। ऐसे प्रश्नों पर शून्य अंक दिये जायेंगे।

11. रफ़ कार्य के लिये प्रश्न-पुस्तिका के मुखपृष्ठ के अन्दर वाले पृष्ठ तथा अंतिम पृष्ठ का प्रयोग करें।

12. परीक्षा के उपरान्त केवल ***ओ०एम०आर० उत्तर-पत्र*** परीक्षा भवन में जमा कर दें।

13. परीक्षा समाप्त होने से पहले परीक्षा भवन से बाहर जाने की अनुमति नहीं होगी।

14. यदि कोई अभ्यर्थी परीक्षा में अनुचित साधनों का प्रयोग करता है, तो वह विश्वविद्यालय द्वारा निर्धारित दंड का/की, भागी होगा/होगी।