

1. Imagine that the Planck's constant changes by the following relation with time $h(t) = \Omega \log(\beta t)$ where $t > 0$ is some arbitrary time scale. The force that experienced by a particle in order to keep its de-Broglie wavelength constant over time is :
- (A) 0
 (B) $\frac{\Omega}{\lambda t}$
 (C) $\frac{\lambda t}{\Omega}$
 (D) $\frac{\lambda t}{\Omega^2}$
2. Which one of the following is true for wave function $\psi(x)$ if $\lim_{x \rightarrow a} V(x) \rightarrow \infty$?
- (A) $\psi(x)$ is continuous and $d\psi(x)/dx$ is discontinuous at $x = a$
 (B) $\psi(x)$ is discontinuous and $d\psi(x)/dx$ is discontinuous at $x = a$
 (C) $\psi(x)$ is discontinuous and $d\psi(x)/dx$ is continuous at $x = a$
 (D) $\psi(x)$ is infinite and $d\psi(x)/dx$ is continuous at $x = a$
3. The operator corresponding to linear momentum p_x is :
- (A) $-i\hbar \frac{d}{dx}$
 (B) $i\hbar \frac{d^2}{dp^2}$
 (C) $-i\hbar \frac{d^2}{dx^2}$
 (D) $i\hbar \frac{d}{dp}$
4. The average value of position of a particle trapped in a one dimensional box of length L is :
- (A) $\frac{L}{4}$
 (B) $\frac{L}{8}$
 (C) $\frac{L^2}{2}$
 (D) $\frac{L}{2}$
5. The term symbol of ground state of Na is $3^2S_{1/2}$, it means :
- (A) $n = 3, l = 0, j = 1/2, m_j = \pm 1/2$
 (B) $n = 4, l = 0, j = 1/2, m_j = \pm 1/2$
 (C) $n = 3, l = 1, j = 1/2, m_j = \pm 1/2$
 (D) $n = 3, l = 1, j = 2, m_j = \pm 1/2$
6. Which of the following is the wrong description of binding energy ?
- (A) It is the energy required to break a nucleus into its constituent nucleons
 (B) It is the energy made available when free nucleons combine to form a nucleus
 (C) It is proportional to the sum of the rest mass energies of its nucleons minus the rest mass energy of the nucleus
 (D) It is the sum of Kinetic energy of all the nucleons in a nucleus

7. Which of the following is an evidence for the existence of neutrons in a nucleus ?
- An atom is always electrically neutral
 - Isotopes are present
 - Some atoms are radioactive in nature
 - All of the above
8. Which of the following is a fundamental particle ?
- Proton
 - Electron
 - Fermion
 - Boson
9. The primitive lattice vectors of a BCC lattice are :
- $[0, 0, 0], [0, 1, 0], \left[\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right]$
 - $[0, 1, 0], [0, 1, 0], \left[\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right]$
 - $[1, 0, 1], [0, 1, 0], \left[\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right]$
 - $[0, 0, 0], [1, 1, 1], \left[\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right]$
10. At low temperatures, the specific heat of a solid as given by Debye theory is :
- Proportional to T^4
 - Proportional to T^3
 - Proportional to T^{-3}
 - None of the above
11. For one dimensional motion of M atoms per unit cell, the number of normal modes for each wave vector is :
- M
 - M^2
 - $M/2$
 - $M - 1$
12. The quantum effects in a copper electrical wire are not dominant because of :
- High lattice vibrations
 - Copper is a conductor
 - High Fermi energy
 - Low heat capacity
13. The ratio of energy gap of silicon to that of diamond is :
- $\frac{1}{100}$
 - $\frac{2}{25}$
 - $\frac{1}{6}$
 - $\frac{1}{2}$
14. The electrical conductivity of a metal with electron relaxation time τ is :
- Independent of τ
 - Inversely proportional to τ
 - Directly proportional to τ
 - Insufficient information

15. In the absence of applied bias voltage, the net flow of charge in any one direction of pn-junction diode is :
- (A) Zero
(B) Non-zero
(C) Non-zero but positive
(D) Always infinite
16. The average current rating of a semiconductor diode is lower than the continuous or peak repetitive forward currents :
- (A) Because a half-wave current waveform will have instantaneous values much higher than the average value
(B) Because a half-wave current waveform will have instantaneous values equal to the average value
(C) Because a half-wave current waveform will have instantaneous values much lesser than the average value
(D) None of the above
17. The relation between current gains α and β of a transistor are related by :
- (A) $\beta = \frac{1-\alpha}{1+\alpha}$
(B) $\beta = \frac{\alpha^2}{1-\alpha^2}$
(C) $\beta = \frac{\alpha}{1-\alpha}$
(D) $\beta = \frac{\alpha^2}{1+\alpha^2}$
18. In a transistor having $\beta = 62$, $R_L = 5000\Omega$ and internal resistance of the transistor is 500Ω . The voltage amplification of the amplifier will be :
- (A) 500
(B) 620
(C) 780
(D) 950
19. MOSFET in electronics stands for :
- (A) Microsoft field transistor
(B) Member of state for electronic technology
(C) Metal-oxide semiconductor field-effect transistor
(D) Metal oxide for state of electronic technology
20. In the cut-off region of a transistor, we have :
- (A) The collector-base and base-emitter junctions are both reverse-biased
(B) Only the collector-base junction is reverse-biased
(C) All are forward biased
(D) None of the above
21. A rod AB of unit length has a linear mass density $\lambda(x) = 3x$, x being measured from the end A. What is the distance of center of mass x_{cm} from the end A ?
- (A) $x_{cm} = 1.3$
(B) $x_{cm} = 10$
(C) $x_{cm} = 1$
(D) $x_{cm} = 0.1$

22. Suppose the coefficient of friction between a horizontal surface and a moving body is μ . With what speed must the body be projected parallel to the surface to travel a distance D before stopping ?
- (A) $v = \sqrt{2D\mu g}$
 (B) $v = \sqrt{4D\mu g}$
 (C) $v = \sqrt{D\mu g}$
 (D) $v = \sqrt{D\mu}$
23. Read the following statements :
- (i) Space is isotropic
 (ii) Space is Euclidean
 (iii) Newton's Laws of motion hold in an inertial frame of reference
 (iv) Newton's Law of Gravitation is valid
- Which one of the above is true for validity of classical mechanics ?
- (A) only (iii)
 (B) (i) and (ii)
 (C) (i), (ii), (iii)
 (D) all (i) to (iv)
24. Relativity of simultaneity means :
- (A) All events are simultaneous
 (B) Simultaneous events in one frame are not simultaneous in another frame
 (C) Simultaneous events in one frame are always simultaneous in another frame
 (D) There is no concept like simultaneity.
25. Moment of inertia I of a disc of radius R and mass M along an axis tangent to the disc and lying in plane of the disc is :
- (A) $I = MR^5$
 (B) $I = MR^2$
 (C) $I = \frac{1}{4} MR^2$
 (D) $I = \frac{5}{4} MR^2$
26. The eccentricity e of some hyperbolic orbits is :
- (A) $e = 0.1$
 (B) $e = 3.0$
 (C) $e = 1$
 (D) $e = 0$
27. Two masses m and M are connected by a rod of length l with negligible mass. If the system is rotating with an angular velocity ω along an axis passing through the center of mass and perpendicular to the rod. The angular momentum of the system is :
- (A) $\frac{mM}{m+M} \omega r^2$
 (B) $\frac{mM}{m-M} \omega r^2$
 (C) $\frac{m+M}{mM} \omega r^2$
 (D) $\frac{m-M}{mM} \omega r^2$

28. The relation between the rotational kinetic energy E , angular momentum L and the moment of inertia I about the same axis is :
- (A) $E = \frac{L^2}{2I}$
- (B) $E = \frac{L^2}{I}$
- (C) $E = \frac{L^2}{4I}$
- (D) $E = \frac{2L^2}{I}$
29. If K is the average K.E. of the simple harmonic oscillator and U its average potential energy then :
- (A) $K = U$
- (B) $K = 2U$
- (C) $U = 2K$
- (D) $U = 4K$
30. The curl of the normal vector to a sphere of radius R is :
- (A) R
- (B) 0
- (C) $1 - R$
- (D) R^{-1}
31. A charge q is located at a perpendicular distance $\frac{l}{2}$ above the center of a square sheet of side l . The flux through the sheet is :
- (A) $\frac{q}{\epsilon_0}$
- (B) $\frac{q}{6\epsilon_0}$
- (C) 0
- (D) $\frac{q}{8\epsilon_0}$
32. Inside which of the following cases, electric field is not constant ?
- (A) Inside a uniformly charged spherical shell
- (B) Inside a spherical cavity of a uniformly charged sphere
- (C) In front of an infinite plane sheet with uniform charge distribution
- (D) At a distance x from a point charge
33. A capacitor is charged to a potential V and then disconnected from the battery. A slab of dielectric constant K is introduced in the slab. The potential difference between the plates of the capacitor after introducing the dielectric is :
- (A) $\frac{V}{K}$
- (B) $\frac{K}{V}$
- (C) $\frac{V}{2K}$
- (D) $\frac{2K}{V}$
34. If magnetic field $\vec{B} = \nabla \times \vec{A}$, \vec{A} being the vector potential, then for constant magnetic field we have :
- (A) $\vec{A} = \frac{1}{2}(\vec{B} \times \vec{r})$
- (B) $\vec{A} = \frac{1}{2}(\vec{r} \times \vec{B})$
- (C) $\vec{A} = (\vec{B} \times \vec{r})$
- (D) 0

35. In a coaxial, straight cable, the central conductor and the outer conductor, carry equal currents in opposite directions. The magnetic field is zero :
- (A) Outside the cable
 (B) Inside the inner conductor
 (C) In between the two conductors
 (D) Inside the outer conductor
36. A steady electric current is flowing through a cylindrical conductor :
- (A) The electric field at the axis of the conductor is zero
 (B) The magnetic field at the axis of the conductor is zero
 (C) The electric field in the vicinity of conductor is non-zero
 (D) The magnetic field in the vicinity of the conductor is zero
37. The relation between electric field and magnetic field amplitudes of an electromagnetic wave travelling in a medium of permeability μ and electric susceptibility χ :
- (A) $E = \frac{B}{\sqrt{2\mu\epsilon_0(1+\chi)}}$
 (B) $B = \frac{E}{\sqrt{\mu\epsilon_0(1+\chi)}}$
 (C) $E = \frac{B}{\sqrt{\mu\epsilon_0(1+\chi)}}$
 (D) $E = \frac{2B}{\sqrt{\mu\epsilon_0(1+\chi)}}$
38. Let us imagine magnetic monopoles exist, how many of Maxwell's equations will be modified ?
- (A) None
 (B) Only one
 (C) Only Two
 (D) All the four equations
39. The average energy flux of an electromagnetic wave travelling in vacuum with electric field varying as $\vec{E}(x, y, z, t) = (\vec{P}\hat{i} + \vec{Q}\hat{j})e^{-i(kz-\omega t)}$ is :
- (A) $\frac{c}{2\mu_0}(P^3 + Q^3)$
 (B) $\frac{c}{\mu_0}(P^2 - Q^2)$
 (C) $\frac{c}{\mu_0}(P^2 + Q^2)$
 (D) $\frac{1}{2c\mu_0}(P^2 + Q^2)$
40. An unpolarized electromagnetic wave of intensity I is made to pass through two polarizers with their axis set at $\pi/4$. The intensity of the wave coming out of the arrangement is :
- (A) 0
 (B) $\frac{I}{4}$
 (C) $\frac{I}{8}$
 (D) $\frac{4}{I}$

41. Specific heat capacity at constant volume in terms of gas constant R and $\gamma = \frac{c_p}{c_v}$ is :
- (A) $C_v = \frac{R}{1-\gamma}$
 (B) $C_v = \frac{R}{\gamma}$
 (C) $C_v = \frac{R}{1+\gamma}$
 (D) $C_v = \frac{1-R}{1-\gamma}$
42. Specific heat capacity in an isothermal process is :
- (A) Infinite
 (B) 0
 (C) Positive but finite
 (D) Incomplete information
43. Entropy change for a reversible process in an isolated system is :
- (A) positive
 (B) equal to zero
 (C) negative
 (D) infinite
44. For a diatomic ideal gas near room temperature, the fraction of the heat supplied Q is available for external work W if the gas is expanded at constant temperature :
- (A) $\frac{W}{Q} = 0$
 (B) $\frac{W}{Q} > 1$
 (C) $\frac{W}{Q} < 1$
 (D) $\frac{W}{Q} = 1$
45. Which of the following is a Maxwell's relation ?
- (A) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$
 (B) $\left(\frac{\partial S}{\partial V}\right)_T = -\left(\frac{\partial P}{\partial T}\right)_V$
 (C) $\left(\frac{\partial P}{\partial T}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$
 (D) $\left(\frac{\partial V}{\partial S}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$
46. The pressure to viscosity ratio of ideal gas :
- (A) varies as T^2
 (B) varies as T
 (C) varies as T^3
 (D) independent of temperature
47. If D is the diffusion coefficient of an ideal gas with average velocity of the particles as v and their average mean free path as λ , then :
- (A) $D = \frac{3}{4} v\lambda$
 (B) $D = \frac{1}{4} v\lambda$
 (C) $D = \frac{2}{3} v\lambda$
 (D) $D = \frac{1}{3} v\lambda$
48. Thermal conductivity of an ideal gas depends on density at fixed temperature due to the fact that :
- (A) global warming is causing more heat
 (B) the speed of gas is undefined
 (C) the collisions are frequent
 (D) none of the above

49. The average energy of a particle if it can be found with equal probability in any one of 10 energy levels accessible to it given that the energy of the levels is $\epsilon_n = n^2 \epsilon_0$ with $n = 1, 2, 3, \dots, 10$:
- (A) $\frac{7}{2} \epsilon_0$
- (B) $\frac{77}{4} \epsilon_0$
- (C) $\frac{1}{2} \epsilon_0$
- (D) $\frac{77}{2} \epsilon_0$
50. If Ω represents the number of microstates, k the Boltzmann constant, then entropy S of the system is :
- (A) $S = k \log_2 \Omega$
- (B) $S = k \log_{10} \Omega$
- (C) $S = k \ln \Omega$
- (D) $S = -k \ln \Omega$
51. Suppose a particle is subjected to one dimensional motion and its energy can be represented by $E(z) = z^2$, the average energy of the particle subjected to Boltzmann Statistics is :
- (A) $\frac{1}{2} kT$
- (B) $\frac{3}{2} kT$
- (C) $\frac{7}{2} kT$
- (D) 0
52. Which Statistics is suitable to describe the density of electrons and holes in semiconducting Ge at room temperature with band gap of 1 volt ?
- (A) Fermi-Dirac Distribution
- (B) Bose-Einstein Distribution
- (C) Maxwell-Boltzmann Distribution
- (D) All of the above
53. The amplitude of the following simple harmonic motion $x(t) = A \cos(\omega t) \hat{i} + \sqrt{2}A \cos\left(\omega t + \frac{\pi}{4}\right) \hat{j}$:
- (A) $\sqrt{5}A$
- (B) $\frac{3}{2}A$
- (C) $\sqrt{7}A$
- (D) $\sqrt{2}A$
54. Given group velocity of a travelling wave is $V_g = \alpha k^3$. The phase velocity at angular frequency ω_0 is :
- (A) $\left(\frac{\omega_0}{4\alpha}\right)^2$
- (B) $\left(\frac{\omega_0}{4\alpha}\right)$
- (C) $\left(\frac{\omega_0}{4\alpha}\right)^{\frac{3}{4}}$
- (D) $\left(\frac{\omega_0}{4\alpha}\right)^{\frac{1}{4}}$

55. If the maximum velocity and acceleration of a particle executing simple harmonic motion are equal in magnitude the time period will be :
- (A) 1.57 sec
 (B) 3.14 sec
 (C) 6.28 sec
 (D) 12.56 sec
56. Two tuning forks produce 4 beats per second. If one of them had frequency 246 Hz and on increasing the frequency of the other the beat frequency is lowered. The frequency in Hz of the latter is :
- (A) 242
 (B) 3
 (C) 205
 (D) 108
57. In a Young's double slit experiment, the interference pattern formed is of the shape :
- (A) Ellipsoidal
 (B) Circular
 (C) Hyperbola
 (D) Straight line
58. What will be the change in visibility of a diffraction pattern if both the maximum and minimum intensities are doubled ?
- (A) Doubled
 (B) Halved
 (C) Quadrupled
 (D) Zero
59. No fringes are seen in a single slit diffraction pattern if :
- (A) The screen is far away
 (B) The wavelength is equal to the slit width
 (C) The wavelength is greater than slit width
 (D) The distance to the screen is greater than that of slit width
60. If D is the distance from slit of width d to the screen with λ to be the wavelength of a coherent source, then distance between adjacent maxima in an interference pattern is :
- (A) $\frac{\lambda D}{d}$
 (B) $\frac{\lambda d}{D}$
 (C) $\frac{D}{\lambda d}$
 (D) $\frac{2\lambda D}{d}$

Sr. No.0137.....

ENTRANCE TEST-2017

SCHOOL OF PHYSICAL AND MATHEMATICAL SCIENCES

PHYSICS

Question Booklet Series

A

Total Questions : 60

Time Allowed : 70 Minutes

Roll No. :

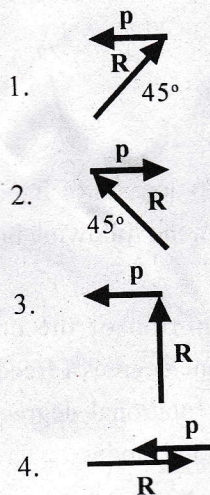
Instructions for Candidates :

1. Write your Roll Number in the space provided at the top of this page of Question Booklet and fill up the necessary information in the spaces provided on the OMR Answer Sheet.
2. OMR Answer Sheet has an Original Copy and a Candidate's Copy glued beneath it at the top. While making entries in the Original Copy, candidate should ensure that the two copies are aligned properly so that the entries made in the Original Copy against each item are exactly copied in the Candidate's Copy.
3. All entries in the OMR Answer Sheet, including answers to questions, are to be recorded in the Original Copy only.
4. Choose the correct / most appropriate response for each question among the options A, B, C and D and darken the circle of the appropriate response completely. The incomplete darkened circle is not correctly read by the OMR Scanner and no complaint to this effect shall be entertained.
5. Use only blue/black ball point pen to darken the circle of correct/most appropriate response. In no case gel/ink pen or pencil should be used.
6. Do not darken more than one circle of options for any question. A question with more than one darkened response shall be considered wrong.
7. There will be 'Negative Marking' for wrong answers. Each wrong answer will lead to the deduction of 0.25 marks from the total score of the candidate.
8. Only those candidates who would obtain positive score in Entrance Test Examination shall be eligible for admission.
9. Do not make any stray mark on the OMR sheet.
10. Calculators and mobiles shall not be permitted inside the examination hall.
11. Rough work, if any, should be done on the blank sheets provided with the question booklet.
12. OMR Answer sheet must be handled carefully and it should not be folded or mutilated in which case it will not be evaluated.
13. Ensure that your OMR Answer Sheet has been signed by the Invigilator and the candidate himself/herself.
14. At the end of the examination, hand over the OMR Answer Sheet to the invigilator who will first tear off the original OMR sheet in presence of the Candidate and hand over the Candidate's Copy to the candidate.

SEAL

1. In how much time will the plane of oscillation of Foucault pendulum turn through 90° at 30° latitude?
- (A) 3 hrs
(B) 6 hrs
(C) 9 hrs
(D) 12 hrs
2. A radioactive nucleus of mass M moving along the positive x -direction with speed v emits an α -particle of mass m . If the α -particle proceeds along the positive y -direction, the centre of mass of the system (made of the daughter nucleus and the α -particle) will
- (A) move along the positive x -direction with speed equal to v
(B) move along the positive x -direction with speed less than v
(C) move along the positive x -direction with speed greater than v
(D) move in a direction inclined to the positive x -direction
3. A person is standing at the edge of a disc of radius R . The disc is rotating about its own axis with uniform angular velocity ω . The person throws a stone in radially outward direction with speed $\frac{\omega R}{2}$ relative to the disc. Acceleration of stone as seen by the person soon after throwing (neglecting gravity) is:
- (A) $\sqrt{7}\omega^2 R$
(B) $\sqrt{2}\omega^2 R$
(C) $\sqrt{5}\omega^2 R$
(D) $2\omega^2 R$
4. Two under-damped oscillators are known to have the same natural frequency ω_0 . The mass and damping coefficient of the first oscillator are m_1 and b_1 , and the mass and damping coefficient of the second oscillator are m_2 and b_2 , respectively. A sinusoidal driving force of $F_{\text{ext}} = F_0 \cos \omega t$ is applied to each oscillator. Starting with ω far from ω_0 , the driving force is tuned in order to observe resonant behavior. If $m_1 = 4m_2$ and $b_1 = 2b_2$, then which one of the following statements concerning the resonant amplitude of the driven oscillations is correct?
- (A) The resonant peak of the first driven oscillator is higher and narrower than that of the second oscillator.
(B) The resonant peak of the first driven oscillator is higher and wider than that of the second oscillator.
(C) The resonant peak of the first driven oscillator is lower and wider than that of the second oscillator.
(D) The resonant peak of the first driven oscillator is lower and narrower than that of the second oscillator.
5. The Coriolis effect is strongest at this latitude:
- (A) 90 degrees
(B) 45 degrees
(C) 30 degrees
(D) 15 degrees
6. Which of the following relations between Force F and potential energy V is correct:
- (A) $F = -\text{grad } V$
(B) $F = -\text{div } V$
(C) $F = -\text{curl } V$
(D) $F = -\text{div } V^2$

7. Which of the following configurations has the largest angular momentum for a given R and p :



- (A) 1
(B) 2
(C) 3
(D) 4

8. The moment of inertia of a body depends on :

- (A) the angular velocity
(B) the angular acceleration
(C) the mass distribution
(D) the torque acting on the body

9. Two particles are moving with speeds $c/2$ and $c/\sqrt{2}$ at 45° to each other. Their relative velocity is:

- (A) $c/\sqrt{3}$
(B) $c/\sqrt{2}$
(C) $c/2$
(D) $c/3$

10. The predictions of Special Relativity appear to us to be counterintuitive because:

- (A) they only apply to the behaviour of microscopic particles, like electrons
(B) they apply only to inanimate objects like clocks and rods, and not to human beings
(C) they are only noticeable at speeds much higher than we normally experience
(D) predictions of special relativity are complex while the world is real

11. An object has the dimensions represented by $(5i + 6j)$ metres in the system S on the ground. System S' is moving with a velocity $0.6c$ w.r.t. ground along the direction of X . The dimensions in the system S' are (i and j are unit vectors)

- (A) $(4i + 6j)$
(B) $(6i + 4j)$
(C) $(4i + 9j)$
(D) $(5i + 4j)$

12. Which of the following is/are conservative vector field/s ?

(i) $F(x, y) = (2x \cos y - y \cos x)i + (-x^2 \sin y - \sin x)j$

(ii) $F(x, y) = (ye^x + \sin y)i + (e^x + x \cos y)j$

- (A) Both (i) and (ii)
(B) (i) but not (ii)
(C) (ii) but not (i)
(D) neither (i) nor (ii)

13. Which of the following statements is false?

- (A) If the electric field is zero in some region of space, the electric potential must also be zero in that region.
(B) The electric lines of force are always perpendicular to the equipotential surfaces.
(C) If the electric potential is zero in some region of space, the electric field must also be zero in that region.
(D) Lines of electric field point towards region of lower potential.

14. Two thin parallel wires are carrying currents along the same direction. The force experienced by one due to the other is

- (A) Parallel to the lines and attractive
(B) Perpendicular to the lines and attractive
(C) Perpendicular to the lines and repulsive
(D) Parallel to the lines and repulsive

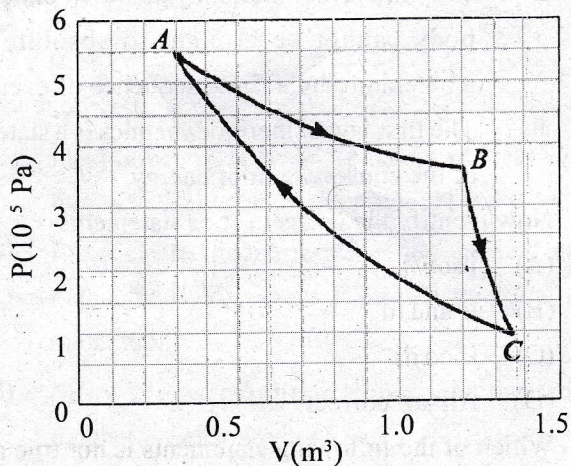
15. The permeability of a material is 0.6421 ($\mu=0.6421$). It implies that the material is (Take $\mu_0 = 4\pi \times 10^{-7}$):
- Paramagnetic
 - Diamagnetic
 - Ferromagnetic
 - Anti-ferromagnetic
16. Line integral of B around a path enclosing a long wire carrying current 20mA is (take $\mu_0 = 4\pi \times 10^{-7}$):
- 8.48×10^{-9} Wbm-2
 - 5.72×10^{-4} Wbm-2
 - 2.51×10^{-8} Wbm-2
 - 7.76×10^{-6} Wbm-2
17. The statement equivalent to $\int_C \mathbf{B} \cdot d\mathbf{l} = \mu_0 I$ is:
- $\nabla \cdot \mathbf{B} = \mu_0 I$
 - $\nabla \times \mathbf{B} = \mu_0 \mathbf{E}$
 - $\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$
 - $\nabla \cdot \mathbf{B} = 0$
18. Which of the following statements is false?
- In an electromagnetic field, the electric and magnetic field energy densities are equal
 - In an electromagnetic wave, the electric and magnetic field vectors E and B are equal in magnitude
 - In an electromagnetic wave, electric and magnetic fields are in phase
 - Electromagnetic waves are transversal
19. The reflection and transmission coefficients of a plane electromagnetic wave incident normally from air on a dielectric surface of refractive index 1.4 are respectively (Take refractive index of air = 1):
- 0.0812 and 0.9188
 - 0.8120 and 0.1880
 - 0.9925 and 0.0075
 - 0.0278 and 0.9722
20. The units of Poynting vector $\mathbf{S} = (\mathbf{E} \times \mathbf{B})/\mu_0$ are:
- $\text{JS}^{-2}\text{m}^{-2}$
 - JSm^{-2}
 - JSm^{-1}
 - $\text{JS}^{-1}\text{m}^{-2}$
21. A diatomic gas molecule has 6 degrees of freedom. For these 6 degrees of freedom, the following break-up is correct
- The center of mass motion of the entire molecule accounts for one degree of freedom. The molecule has two rotational degrees of motion and three vibrational modes.
 - The center of mass motion of the entire molecule accounts for one degree of freedom. The molecule has three rotational degrees of motion and two vibrational modes.
 - The center of mass motion of the entire molecule accounts for 3 degrees of freedom. The molecule has two rotational degrees of motion and one vibrational mode.
 - The center of mass motion of the entire molecule accounts for 3 degrees of freedom. The molecule has three rotational degrees of motion and two vibrational modes.
22. A real gas obeying van der Waal's equation will resemble ideal gas if:
- both 'a' and 'b' are large
 - both 'a' and 'b' are small
 - 'a' is small and 'b' is large
 - 'a' is large and 'b' is small
23. The entropy of a four coin system, if all the four coins are heads up, is
- 0
 - 1.5 J/K
 - 3.7 J/K
 - 9.2 J/K

24. The ratio of the specific heats $\gamma (=C_p/C_v)$ for monoatomic, diatomic and triatomic gases is respectively:
- (A) 0.75, 1.5, 2.25
 (B) 1.33, 1.40, 1.66
 (C) 1.66, 1.40, 1.33
 (D) 2.25, 1.5, 0.75
25. The Joule-Thomson (J-T) effect is a thermodynamic process that occurs when
- (A) a fluid expands from low temperature to high temperature at constant pressure.
 (B) a fluid expands from high pressure to low pressure at constant enthalpy.
 (C) a fluid expands from low temperature to high temperature at constant volume.
 (D) a fluid contracts from low temperature to high temperature at constant pressure.
26. At what temperature will the average molecular kinetic energy in gaseous hydrogen equal the binding energy of a hydrogen atom?
- (A) 164300 K
 (B) 16430 K
 (C) 26300 K
 (D) 105200 K
27. A box contains 10 balls that could be either red or blue. How many different microstates satisfy the macrostate of exactly 3 of the balls being red?
- (A) 7
 (B) 30
 (C) 82
 (D) 120
28. For a system of two particles, each of spin s , the ratio of the number of symmetrical to the number of anti-symmetrical spin states is
- (A) $\frac{s^2 + 1}{s}$
 (B) $\frac{s + 1}{s}$
 (C) $\frac{1}{s}$
 (D) $\frac{s}{s + 1}$
29. Read the following statements:
- The second law of thermodynamics implies that all natural processes lead to an increase in entropy.
 - The third law of thermodynamics implies that a body cannot be brought to absolute zero temperature by a finite sequence of events.
 - The first law of thermodynamics is a statement of the conservation of energy.
- Now identify the correct set of statements:
- (A) i and ii
 (B) ii and iii
 (C) i and iii
 (D) All are correct
30. Which of the following statements is not true about Bose Einstein statistics ?
- (A) It describes identical, distinguishable particles obeying Pauli exclusion principle.
 (B) The wave functions of particles obeying Bose Einstein statistics are symmetric to interchange of particles.
 (C) Some examples of particles obeying the statistics are Photons in a cavity, Phonons in a solid.
 (D) In this statistics, there is no limit to the number of particles per state.

31. According to the fundamental assumption of Statistical Mechanics, which of the following states of an atom with three degrees of freedom and three quanta of energy is most probable?

- (A) One degree of freedom with 3 quanta of energy and two degrees of freedom with 0 quanta of energy each.
- (B) One degree of freedom with 2 quanta of energy, one degree of freedom with 1 quantum of energy, and one degree of freedom with 0 quanta of energy.
- (C) Three degrees of freedom with 1 quantum of energy each.
- (D) None of the above, because all microstates are equally probable.

32. The net work done in the thermodynamic cycle ABCA shown in the figure below is:



- (A) 110 kJ
 - (B) 1100 kJ
 - (C) 11000 kJ
 - (D) 1100 J
33. Light waves from two coherent sources having intensities I and $2I$ cross each other at a point with a phase difference of 30° . The resultant intensity at that point is:
- (A) $9.45I$.
 - (B) $5.45I$.
 - (C) $4.34I$.
 - (D) $6.45I$.

34. The motion of a particle described by $x = A\sin(\omega t) + B\cos(\omega t)$ is :

- (A) not simple harmonic
- (B) Simple harmonic with amplitude $A+B$
- (C) Simple harmonic with amplitude $(A+B)/2$
- (D) Simple harmonic with amplitude $\sqrt{A^2 + B^2}$

35. In Fabry-Perot interferometer, maximum transmission occurs when path length difference is equal to (neglecting absorption):

- (A) $n\lambda$
- (B) $(n+1)\lambda$
- (C) $\frac{n\lambda}{2}$
- (D) $\frac{(2n+1)\lambda}{2}$

36. When the movable mirror of a Michelson interferometer is shifted through 0.0589 mm, a shift of 200 fringes is obtained. The wavelength of light used is (take $\cos\theta_m = 1$):

- (A) 589 nm
- (B) 420 nm
- (C) 520 nm
- (D) 638 nm

37. Radius of first zone in a plate of principal focal length 20cm for light of wavelength 5000 Å is:

- (A) 0.916 mm
- (B) 0.291 mm
- (C) 0.316 mm
- (D) 0.496 mm

38. In Fraunhofer diffraction pattern of a double slit, there are eleven bright fringes within the central diffraction peak. If each slit is 0.020 cm wide, then the separation between them is:

- (A) 0.134 cm
- (B) 0.214 cm
- (C) 0.019 cm
- (D) 0.324 cm

39. Read the following statements regarding the polarization by reflection :

- (i) Percentage of the polarized light in the reflected beam is greater at the angle of polarization.
- (ii) Reflected light is circularly polarized in the plane of incidence.
- (iii) The degree of polarization varies with the angle of incidence.
- (iv) Reflected light is plane polarized in the plane perpendicular to the incident plane

Now identify the correct set of statements:

- (A) (i) and (ii)
- (B) (ii) and (iii)
- (C) (iii) and (iv)
- (D) (i) and (iii)

40. The total energy of an electron in the ground state of the Hydrogen atom is -13.6 eV . The electron's kinetic energy is

- (A) 13.6 eV
- (B) 27.2 eV
- (C) 6.8 eV
- (D) 54.4 eV

41. Optically active substances are those substances which:

- (A) Produce polarized light.
- (B) Rotate the plane of polarization of polarized light.
- (C) Produce double refraction.
- (D) Convert a plane polarized light into circularly polarized light.

Amr / Jalib

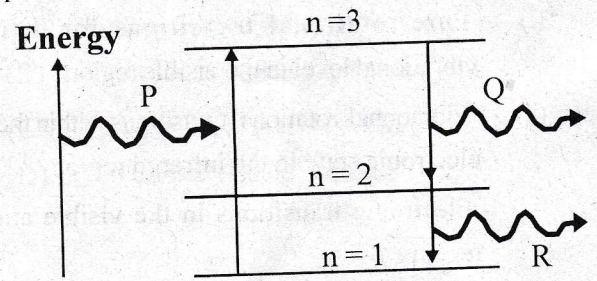
42. Compton, in the analysis of his experiment on Scattering of X ray Photons, used

- (A) De Broglie relation
- (B) Principle of conservation of energy
- (C) Einstein's concept of photon
- (D) Principle of conservation of momentum

43. In order to explain the spectral energy density of blackbody radiation, Planck had to assume that

- (A) the number of photons inside the blackbody was conserved
- (B) the oscillators in the cavity walls were limited to quantized energies
- (C) the oscillators in the cavity walls obeyed Maxwell-Boltzmann statistics
- (D) the classical particles are indistinguishable

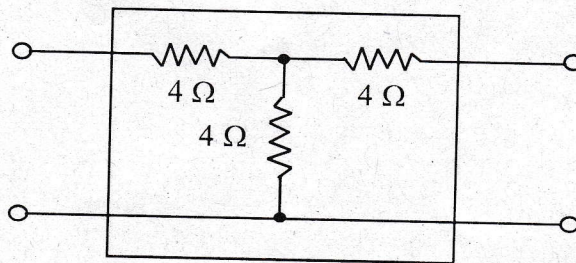
44. Photon P in Figure (below) moves an electron from energy level $n = 1$ to energy level $n = 3$. The electron jumps down to $n = 2$, emitting photon Q, and then jumps down to $n = 1$, emitting photon R. The spacing between energy levels is drawn to scale. What is the correct relationship among the wavelengths of the photons?



- (A) $\lambda_P < \lambda_Q < \lambda_R$
- (B) $\lambda_P > \lambda_Q < \lambda_R$
- (C) $\lambda_P < \lambda_Q > \lambda_R$
- (D) $\lambda_P > \lambda_Q > \lambda_R$

45. $\psi(x) = \exp(-x^2/2)$ is an eigen function of the operator $A = \frac{\partial^2}{\partial x^2} - x^2$. The corresponding eigen value is
- (A) $-x$
 (B) 3
 (C) $-1/4$
 (D) -1
46. The expectation value of the momentum of a free particle $\langle p \rangle$ described by the wave function $\psi(x, t) = Ae^{i(kx - \omega t)}$ moving in a one dimensional space of zero potential from $x = -\infty$ to $x = +\infty$ is
- (A) 0
 (B) $hk/2\pi$
 (C) $h\omega/2\pi$
 (D) ∞
47. The anomalous Zeeman effect can be explained if we take into account
- (A) the electron spin
 (B) the electron orbital angular momentum
 (C) the electron linear momentum as well as orbital angular momentum
 (D) electron mass, speed and magnetic moment
48. The absorption or emission spectra of a diatomic molecule consists of:
- (i) Pure rotational transitions for different vibrational level in the visible region
 (ii) Vibrational-rotational transitions within the same electronic state in the infrared region
 (iii) Electronic transitions in the visible and UV region
- Now choose the correct set of statements :
- (A) (i) and (ii)
 (B) (ii) and (iii)
 (C) (i) and (iii)
 (D) all are correct
49. If the stable isotope of sodium is ^{23}Na , what kind of radioactivity would you expect from
- (i) ^{22}Na and
 (ii) ^{24}Na ?
- (A) ^{22}Na can undergo an inverse β decay while ^{24}Na can undergo a β decay
 (B) ^{22}Na can undergo a β decay while ^{24}Na can undergo an α decay
 (C) ^{22}Na can undergo an α decay while ^{24}Na can undergo a β decay
 (D) Both can decay by α and β emission
50. The reaction $n \rightarrow p + \pi^-$ is not an allowed reaction as:
- (A) it violates baryon number conservation
 (B) strangeness is violated
 (C) it violates energy-momentum conservation
 (D) it does not violate any conservation law and is an allowed reaction
51. Which of the following is NOT a characteristic of a neutrino?
- (A) It generally is produced in beta-decay.
 (B) It is a massless particle, or at least nearly so.
 (C) It interacts readily with other particles.
 (D) It is the second most abundant particle in the universe.
52. The particles that are all fermions and are unaffected by the strong interaction are:
- (A) Gravitons
 (B) Hadrons
 (C) Mesons
 (D) Leptons

53. Considering the packing factor, among the cubic crystals the most closely packed structure is:
- Simple Cubic
 - Base centered Cubic
 - Body centered cubic
 - Face centered cubic
54. The Miller indices of a plane having intercepts $4a$, $2b$, $3c$ on the a , b , c axes respectively are
- (324)
 - (342)
 - (364)
 - (423)
55. The form of the potential in the Kronig-Penney model is
- periodic square wave
 - simple Coulomb potential
 - screened Coulomb potential
 - Yukawa potential
56. The probability that an electron in a metal occupies the Fermi-level, at any temperature (> 0 K) is
- 0
 - 0.25
 - 0.5
 - 1
57. Hall effect is observed in a specimen when it (metal or a semiconductor) is carrying current and is placed in a magnetic field. The resultant electric field inside the specimen will be in a direction:
- normal to current and parallel to magnetic field
 - normal to magnetic field but parallel to current
 - parallel to both current and magnetic field
 - normal to both current and magnetic field
58. For a JFET, when V_{DS} is increased beyond the pinch off voltage, the drain current
- Increases exponentially
 - Decreases exponentially
 - Remains constant
 - Decreases linearly
59. The Hybrid parameters h_{11} (input impedance with output shorted), h_{21} (current gain with output shorted), h_{12} (voltage feedback ratio with input terminals open) for the circuit shown below are, respectively



- $10 \Omega, 4, -4$
 - $8 \Omega, 2, -2$
 - $4 \Omega, -4, 2$
 - $6 \Omega, -0.5, 0.5$
60. MOSFET can be used as
- Voltage controlled capacitor
 - Current controlled capacitor
 - Voltage controlled inductor
 - Current controlled inductor

Sr. No.0037

ENTRANCE TEST-2016

FACULTY OF PHYSICAL AND MATERIAL SCIENCE

M.Sc. PHYSICS

Total Questions : 60

Question Booklet Series

A

Time Allowed : 70 Minutes

Roll No. :

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Instructions for Candidates :

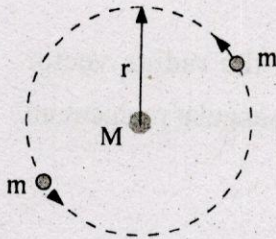
1. Write your Roll Number in the space provided at the top of this page of Question Booklet and fill up the necessary information in the spaces provided on the OMR Answer Sheet.
2. OMR Answer Sheet has an Original Copy and a Candidate's Copy glued beneath it at the top. While making entries in the Original Copy, candidate should ensure that the two copies are aligned properly so that the entries made in the Original Copy against each item are exactly copied in the Candidate's Copy.
3. All entries in the OMR Answer Sheet, including answers to questions, are to be recorded in the Original Copy only.
4. Choose the correct / most appropriate response for each question among the options A, B, C and D and darken the circle of the appropriate response completely. The incomplete darkened circle is not correctly read by the OMR Scanner and no complaint to this effect shall be entertained.
5. Use only blue/black ball point pen to darken the circle of correct/most appropriate response. In no case gel/ink pen or pencil should be used.
6. Do not darken more than one circle of options for any question. A question with more than one darkened response shall be considered wrong.
7. There will be 'Negative Marking' for wrong answers. Each wrong answer will lead to the deduction of 0.25 marks from the total score of the candidate.
8. Only those candidates who would obtain positive score in Entrance Test Examination shall be eligible for admission.
9. Do not make any stray mark on the OMR sheet.
10. Calculators and mobiles shall not be permitted inside the examination hall.
11. Rough work, if any, should be done on the blank sheets provided with the question booklet.
12. OMR Answer sheet must be handled carefully and it should not be folded or mutilated in which case it will not be evaluated.
13. Ensure that your OMR Answer Sheet has been signed by the Invigilator and the candidate himself/herself.
14. At the end of the examination, hand over the OMR Answer Sheet to the invigilator who will first tear off the original OMR sheet in presence of the Candidate and hand over the Candidate's Copy to the candidate.

SEAL

4. The centre of mass of a uniform solid hemisphere of radius r is :
- (A) $2r/3$ (B) $3r/4$
 (C) $r/4$ (D) $3r/8$
5. An object-spring system moving with simple harmonic motion has an amplitude A . When the kinetic energy of the object equals twice the potential energy stored in the spring, what is the position x of the object ?

- (A) $\frac{A}{\sqrt{2}}$ (B) $\frac{A}{\sqrt{3}}$
 (C) $\frac{A}{2\sqrt{3}}$ (D) $\frac{A}{2\sqrt{2}}$

6. A certain triple-star system consists of two stars, each of mass m , revolving in the same circular orbit of radius r around a central star of mass M . The two orbiting stars are always at opposite ends of a diameter of the orbit. The magnitude of the net gravitational force on one of the smaller stars (of mass m) is :



- (A) $\frac{Gm}{r^2} \left(M + \frac{m}{4} \right)$ (B) $\frac{GM}{r^2} \left(M + \frac{m}{2} \right)$
 (C) $\frac{GM}{r^2} \left(M - \frac{m}{4} \right)$ (D) $\frac{Gm}{r^2} \left(m - \frac{M}{4} \right)$

7. Which of the following statements is not true about moments and products of inertia ?
- (A) Moments of inertia are always positive
 (B) If a particular plane is a plane of symmetry, then the products of inertia associated with any axis perpendicular to that plane are non-zero positive
 (C) Moments of inertia of a body about a particular axis are a measure of the distribution of the body's mass about that axis
 (D) Products of inertia can be positive, negative or zero

8. According to Michelson-Morley experiment :
- (A) The speed of light is invariant
 - (B) The speed of light depends on the speed of observer
 - (C) The speed of light depends on the speed of source
 - (D) The speed of light in vacuum depends on both the relative motion of the observer and that of source
9. An electron has a momentum with magnitude three times the magnitude of its classical momentum. The speed of the electron is :
- (A) $\frac{2}{\sqrt{3}} C$
 - (B) $\frac{\sqrt{2}}{3} C$
 - (C) $\frac{2\sqrt{2}}{3} C$
 - (D) $\frac{\sqrt{2}}{\sqrt{3}} C$
10. A distant astronomical object (a quasar) is moving away from us at half the speed of light. What is the speed of the light we receive from this quasar ?
- (A) Greater than C
 - (B) C
 - (C) C/2
 - (D) Between 0 and C/2
11. The trajectory of a particle of unit mass is given by the radius vector $\vec{r} = a \cos \omega t \hat{i} + b \sin \omega t \hat{j}$, where a and b are constants. The angular momentum of the particle about the origin is :
- (A) $ab\omega^2 \hat{k}$
 - (B) $ab^2\omega \hat{j}$
 - (C) $ab\omega \hat{k}$
 - (D) $a^2b\omega \hat{i}$
12. The value of $\int_0^2 x^2 \delta(x-3) dx$ where δ is the Dirac Delta function is :
- (A) 0
 - (B) 2
 - (C) 3
 - (D) 9
13. A neutral water molecule in its vapour state has an electric dipole moment of magnitude 6.2×10^{-30} C.m. How far apart are the molecule's centers of positive and negative charge ? Recall that in a neutral water molecule there are 10 electrons and 10 protons.
- (A) 3.9×10^{-4} m
 - (B) 3.9×10^{-6} m
 - (C) 3.9×10^{-8} m
 - (D) 3.9×10^{-12} m

14. Which of the following is a correct statement of the Poynting theorem in electrodynamics ?
- (A) The increase in the electromagnetic energy per unit time in a certain volume is equal to the difference of work done by the field forces and the net outward flux per unit time
 - (B) The decrease in the electromagnetic energy per unit time in a certain volume is equal to the sum of work done by the field forces and the net outward flux per unit time
 - (C) The ratio of thermal to electric conductivity is a constant in a constant magnetic field
 - (D) The ratio of thermal to electric conductivity is a constant in a constant electric field
15. Consider an electric dipole harmonically oscillating with an angular frequency ω . The power radiated by this dipole is proportional to :
- (A) ω
 - (B) ω^2
 - (C) $\sqrt{\omega}$
 - (D) ω^4
16. If we combine two linearly polarized waves of equal amplitude, one polarized in the x direction, and one in the y direction, that oscillate $\pi/2$ radians out of phase, the result is :
- (A) A doubly polarized wave
 - (B) A circularly polarized wave
 - (C) An elliptically polarized wave
 - (D) An unpolarized wave
17. If a system could be built where a time-varying electric field E is always parallel to a time varying magnetic field H at every point in space, what would be the nature of the electromagnetic energy flow ?
- (A) Energy would flow parallel to the E field, but in the opposite direction
 - (B) Energy would flow parallel to the E field, but in the same direction
 - (C) Energy would flow perpendicular to the E field
 - (D) There would be no energy flow
18. Maxwell introduced the displacement current as a correction to :
- (A) Amperé's law
 - (B) Faraday's law
 - (C) Biot Savart's law
 - (D) Gauss's law

19. When an electromagnetic wave passes from one medium to another :
- (A) Its wavelength changes while the frequency remains the same
 - (B) Its frequency changes while the wavelength remains the same
 - (C) Both its wavelength and frequency change
 - (D) Neither the wavelength nor the frequency change
20. Maxwell's stress tensor :
- (A) is symmetric
 - (B) is anti symmetric
 - (C) is skew symmetric
 - (D) has no particular symmetry
21. Each molecule of a gas has n degrees of freedom. The ratio C_p/C_v for the gas is :
- (A) $n(n-1)/2$
 - (B) $\frac{n}{n^2 + 1}$
 - (C) $\frac{n^2}{n + 1}$
 - (D) $1 + \frac{2}{n}$
22. The specific heat C_v of a metal has an electronic contribution and a contribution from lattice vibrations. These contributions are respectively proportional to :
- (A) T and T^2
 - (B) T and T^3
 - (C) T^2 and T
 - (D) T^3 and T
23. If v_p , v_{rms} and v_{mean} represent the most probable velocity, root mean square velocity and the mean velocity of molecules respectively, then according to Maxwell's velocity distribution law :
- (A) $v_p < v_{mean} < v_{rms}$
 - (B) $v_p > v_{mean} > v_{rms}$
 - (C) $v_p < v_{mean} > v_{rms}$
 - (D) $v_p > v_{mean} < v_{rms}$
24. For a diatomic ideal gas near room temperature, what fraction of the heat supplied is available for external work if the gas is expanded at constant pressure ?
- (A) $2/3$
 - (B) $3/2$
 - (C) $1/5$
 - (D) $2/7$
25. An ideal gas is expanded isothermally such that its volume is doubled. What is the change in the internal energy of the gas ?
- (A) The internal energy is halved
 - (B) The internal energy is quadrupled
 - (C) The internal energy is also doubled
 - (D) The internal energy does not change

26. Three systems A, B and C are almost independent of each other. Suppose they interact with each other weakly so that they can be regarded as a compound system $A + B + C$. If Z_A , Z_B and Z_C are the partition functions of the individual systems, then the partition function of the combined system $Z_{A+B+C} =$
- (A) $Z_A Z_B Z_C$ (B) $Z_A + Z_B + Z_C$
 (C) $1/Z_A + 1/Z_B + 1/Z_C$ (D) $1/(Z_A Z_B Z_C)$
27. Beta decay occurs by the emission of a beta particle and a neutrino. The role of the neutrino is to :
- (A) Carry away one unit of positive charge
 (B) Carry away one unit of negative charge
 (C) Carry away both momentum and energy
 (D) Carry away momentum only, but no energy, since it is massless
28. Consider a box divided into two equal parts, with a removable partition. Initially there are 5 particles all in the left half of the box. When the partition is removed, the system achieves equilibrium after some time. The probability that all the 5 particles would still be in the left half of the box is :
- (A) 0.03 (B) 0.13
 (C) 0.21 (D) 0.32
29. If you have to give one example each of particles obeying FD (Fermi-Dirac), BE (Bose-Einstein) and MB (Maxwell-Boltzmann) statistics, then (i) *free electrons in a metal*, (ii) *molecules of a gas*, (iii) *photons in a cavity* will respectively serve examples of :
- (A) (i) FD; (ii) BE; (iii) MB (B) (i) MB; (ii) BE; (iii) FD
 (C) (i) BE; (ii) FD; (iii) MB (D) (i) FD; (ii) MB; (iii) BE
30. An object is at a temperature of 400°C . At what temperature would it radiate energy twice as fast ?
- (A) 800°C (B) 1600°C
 (C) 953°C (D) 527°C
31. Six distinguishable particles are distributed over three non-degenerate levels of energies 0, E and 2E. The total energy of the distribution for which the probability is a maximum is:
- (A) 3E (B) 6E
 (C) 18E (D) 24E

32. Three coins are flipped simultaneously. The probability of getting two heads is :
- (A) $2/3$ (B) $3/4$
(C) $3/8$ (D) $1/3$
33. How many normal modes of vibration are possible for a benzene molecule (degrees of freedom = 12) ?
- (A) 10 (B) 30
(C) 36 (D) 72
34. Consider the wave equation $\frac{\partial^2 y}{\partial x^2} = b \frac{\partial^2 y}{\partial t^2}$. What is the speed of wave governed by this equation ?
- (A) b (B) b^2
(C) \sqrt{b} (D) $1/\sqrt{b}$
35. In a two-slit experiment with coherent light, the intensity of light reaching the center of screen from one slit alone is I and the intensity of the light reaching the center from the other slit alone is $9I$. When both slits are open, what is the intensity of light at the interference minima nearest the center ? Assume the slits are very narrow.
- (A) $10 I$ (B) $8 I$
(C) $4 I$ (D) $3 I$
36. The energy carried by a wave is proportional to :
- (A) its amplitude
(B) inverse square root of its amplitude
(C) square root of its amplitude
(D) square of its amplitude
37. For a plane wave incident normally on a circular aperture of radius a , the intensity variation on an axial point R is given by $I = I_0 \sin^2 \frac{p\pi}{2}$. If λ is the wavelength and d is the distance of the point R from the centre of the aperture, then the p appearing in the expression is :
- (A) $p = \frac{a\lambda}{d^2}$ (B) $p = \frac{d\lambda}{a^2}$
(C) $p = \frac{a^2}{d\lambda}$ (D) $p = \frac{ad}{\lambda^2}$

38. Unpolarized light is incident upon two polarizers. The first polarizer has a vertical transmission axis, the second has a transmission axis rotated 30.0° with respect to the first. If the initial light intensity of the beam is X , the light intensity after the beam passes through the second polarizer is :

(A) $\frac{1}{8}X$

(B) $\frac{1}{4}X$

(C) $\frac{3}{8}X$

(D) $\frac{3}{16}X$

39. The de Broglie wavelength of an electron is 6600 Angstrom. Given, $m_e = 10^{-30}$ Kg and $h = 6.6 \times 10^{-34}$ Js, the kinetic energy of the electron is nearly :

(A) 3×10^{-3} eV

(B) 3×10^{-6} eV

(C) 3×10^{-9} eV

(D) 3×10^{-12} eV

40. A particle is confined to a one dimensional box of finite length with perfectly rigid walls. If E_1 is the energy of the lowest energy level, then the difference in energies between the n^{th} level and the $(n + 1)^{\text{th}}$ level is :

(A) $(n^2 + 1)E_1$

(B) $(n^2 - 1)E_1$

(C) $(2n + 1)E_1$

(D) $(2n - 1)E_1$

41. Which of the following sets of quantum numbers is not allowed for the hydrogen atom in its first excited state ?

(A) $n = 2, l = 0, m = 1$

(B) $n = 2, l = 1, m = 1$

(C) $n = 2, l = 1, m = -1$

(D) $n = 2, l = 0, m = 0$

42. A proton, electron and a helium nucleus all move at speed v . Rank their de Broglie wavelengths from longest to shortest.

(A) Proton, Helium nucleus, Electron (B) Helium nucleus, Proton, Electron

(C) Proton, Electron, Helium nucleus (D) Electron, Proton, Helium nucleus

43. A moving particle is described by the wave function $\psi(x, t)$ at a point x in the element dx . The value of $|\psi|^2 dx$ is proportional to particle's :

(A) Electric field

(B) Energy

(C) Momentum

(D) Probability of being found

44. Read the following statements :

- (i) Wave phenomena are not observed for macroscopic objects such as a cricket ball because the wavelength associated with such objects is too long
- (ii) The principal quantum number of the electron in a hydrogen atom does not affect its energy
- (iii) An electron with a positive total energy is a bound electron
- (iv) Orbital angular momentum of an electron in its ground state is zero

Now identify the correct set of statements :

- (A) (i) and (iii)
- (B) (i) and (iv)
- (C) (ii) and (iv)
- (D) (ii) and (iii)

45. The operator $\left(\frac{d}{dx} + x\right)^2 =$

- (A) $\frac{d^2}{dx^2} + x^2 + 2$
- (B) $\frac{d^2}{dx^2} + x^2 + 2x \frac{d}{dx}$
- (C) $\frac{d^2}{dx^2} + x^2 + 2x \frac{d}{dx} + 1$
- (D) $\frac{d^2}{dx^2} + x^2 + x \frac{d}{dx} + 1$

46. Ground state energy of the hydrogen atom is -13.6 eV. How much energy does the electron (initially in the ground state) have to absorb to make a transition to the first excited state ?

- (A) 6.8 eV
- (B) 3.4 eV
- (C) 13.6 eV
- (D) 10.2 eV

47. From our knowledge of the known stable nuclei, we can infer that for every nucleus with odd number of protons and odd number of neutrons, there are nearly the following number of nuclei with even number of protons and even number of neutrons :

- (A) 40
- (B) 12
- (C) 13
- (D) 4

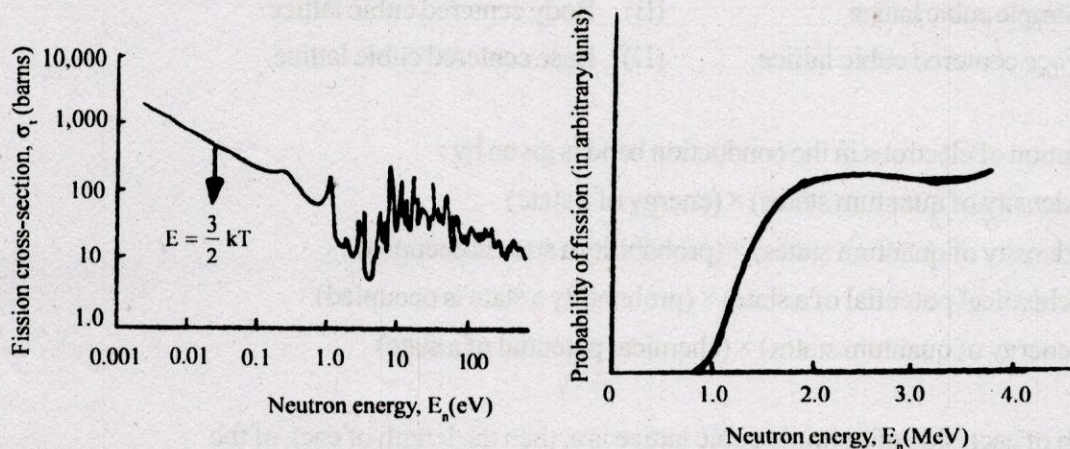
48. If the expectation value of the momentum is $\langle p \rangle$ for the wavefunction $\psi(x)$, then the expectation value of momentum for the wavefunction $e^{2\pi i k x / h} \psi(x)$ is :

- (A) $\langle p \rangle - k \langle x \rangle^2$
- (B) $\langle p \rangle + k \langle x \rangle$
- (C) $\langle p \rangle$
- (D) $\langle p \rangle + k$

49. The Kronig Penney model that describes the general characteristics of the quantum behaviour of electrons in solids assumes :

- (A) A central potential (B) A periodic potential
(C) A screened coulomb potential (D) Yukawa potential

50. Look at the following two figures. Now based on your knowledge of nuclear fission, which of the following statements is correct ?



- (A) The left one seems to correspond to ^{235}U while the right one to ^{238}U
(B) The left one seems to correspond to ^{238}U while the right one to ^{235}U
(C) Whether it is ^{235}U or ^{238}U , one of the figures is incorrect
(D) This is one of the examples of discrepancies in nuclear physics. The cross sections are never consistent with the probabilities

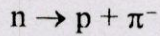
51. Binding energy per nucleon is a measure of :

- (A) Size of the nucleus
(B) Angular momentum of the nucleus
(C) Stability of the nucleus
(D) Strength of the nuclear force

52. When an electron and a positron meet at low speed in empty space, they annihilate each other to produce two 0.511-MeV gamma rays. What law would be violated if they produced one gamma ray with an energy of 1.02 MeV ?

- (A) Conservation of energy (B) Conservation of momentum
(C) Conservation of charge (D) Conservation of baryon number

53. Which conservation law is violated in the following decay process :



- (A) Electric charge (B) Baryon number
(C) Angular momentum (D) Energy

54. Among the following crystal systems, the most efficient packing arrangement can be found in :

- (A) Simple cubic lattice (B) Body centered cubic lattice
(C) Face centered cubic lattice (D) Base centered cubic lattice

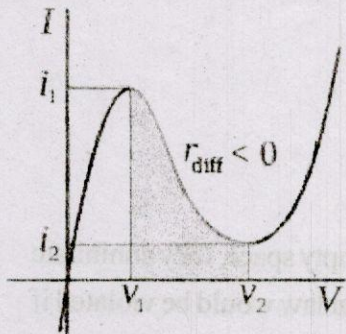
55. The distribution of electrons in the conduction band is given by :

- (A) (density of quantum states) \times (energy of a state)
(B) (density of quantum states) \times (probability a state is occupied)
(C) (chemical potential of a state) \times (probability a state is occupied)
(D) (energy of quantum states) \times (chemical potential of a state)

56. If the length of each side of a simple cubic lattice is a , then the length of each of the sides of its reciprocal lattice is :

- (A) $\frac{\pi}{a^2}$ (B) $\frac{2\pi}{a}$
(C) $\frac{4\pi}{a^2}$ (D) $2\pi a$

57. The following graphs shows the V-I Characteristics of a :



- (A) PNP transistor (B) FET
(C) MOSFET (D) Tunnel diode

58. The voltage divider biasing circuits is used in amplifiers quite often because it :
- (A) Limits the AC signal going to base
 - (B) Makes the operating point almost independent of β
 - (C) Reduces the DC base electric current
 - (D) Reduces the cost of the circuit
59. A depletion MOSFET differs from a JFET in the sense that it has no :
- (A) Channel
 - (B) Gate
 - (C) Substrate
 - (D) p-n junction
60. A single stage amplifier has a voltage gain of 60. The collector load $R_C = 500 \Omega$ and the input impedance is $1 \text{ k}\Omega$. Calculate the overall gain when two such stages are cascaded through R-C coupling :
- (A) 3442
 - (B) 120
 - (C) 2397
 - (D) 3593

ROUGH WORK

1. The surface area element in spherical polar coordinate system can be written as :
(A) $r^2 \sin\theta dr d\theta d\phi$ (B) $r^2 \sin^2\theta dr d\theta d\phi$
(C) $r^2 \sin\theta d\theta d\phi$ (D) $r \sin\theta dr d\theta d\phi$
2. The Earth completes one orbit about the Sun in 1 year and has an orbital radius of 1.50×10^{11} m. If the orbital radius of Jupiter is 7.78×10^{11} m, the period of Jupiter's orbit is nearly equal to :
(A) $9 \times$ Time period of Earth
(B) $10 \times$ Time period of Earth
(C) $8 \times$ Time period of Earth
(D) $12 \times$ Time period of Earth
3. If a particle moves in an elliptical path under a force which is always directed towards its focus, then its acceleration varies as :
(A) inversely as the square of the distance of the particle from the focus
(B) directly as the square of the distance of the particle from the focus
(C) inversely as the cube of the distance of the particle from the focus
(D) directly as the cube of the distance of the particle from the focus
4. A person sitting firmly over a rotating stool has his arms stretched. If he folds his arms, his angular momentum about the axis of rotation :
(A) increases (B) decreases
(C) doubles (D) remains unchanged
5. Which of the following statements is NOT CORRECT ?
(A) Two frames which are at rest with respect to each other or moving with constant velocity with respect to each other on a straight line are called inertial reference frames
(B) Newton's laws of motion are valid only for inertia reference frame
(C) Newton's laws of motion are valid for both inertial and non-inertial reference frames
(D) Non-inertial frame of reference involves pseudo-forces which do not exist physically

6. In classical mechanics, the natural form of the Lagrangian, L is defined as :

- (A) $L = T + V$ (B) $L = T - V$
(C) $L = 2T + V$ (D) $L = V - T$

where T is Kinetic energy and V , Potential energy.

7. Which of the following statements is NOT CORRECT ?

- (A) Due to the Coriolis effect, a fluid moving horizontally in the northern hemisphere tends to be deflected to the right of its path of motion
(B) Due to the Coriolis effect, a fluid moving horizontally in the southern hemisphere tends to be deflected to the left of its path of motion
(C) The Coriolis effect is absent at the equator but increases in strength toward the poles
(D) The Coriolis effect is maximum at the equator but decreases in strength toward the poles

8. The Lagrangian of a simple pendulum can be written as :

- (A) $L = \frac{1}{2} ml^2 \dot{\theta}^2 - mgl(1 - \cos\theta)$ (B) $L = \frac{1}{2} ml \dot{\theta}^2 - mgl(1 - \cos\theta)$
(C) $L = \frac{1}{2} ml^2 \dot{\theta} - mgl(1 - \cos\theta)$ (D) $L = \frac{1}{2} ml^2 - mgl(1 - \cos\theta)$

where $\dot{\theta} = \frac{\partial\theta}{\partial t}$ and l is the length of the pendulum.

9. Which of the following statements is NOT CORRECT ?

- (A) According to the principle of relativity, absolute uniform motion can be detected
(B) According to Einstein, 'time' depends on the frame of reference
(C) The special theory of relativity is a physical theory of time and space without gravity
(D) The speed of light is the same for all observers, no matter what their relative speeds

10. A spacecraft moves at a speed of $0.90c$. If its length is L as measured by an observer on the spacecraft, what is the length measured by an observer on the ground ?

- (A) $0.436 L$ (B) $43.6 \times 10^{-6} L$
(C) $0.0436 L$ (D) L

11. The velocity of an electron which has a kinetic energy of 10 MeV is (approx.):

- (A) $0.868 c$ (B) $0.908 c$
(C) $0.998 c$ (D) $0.828 c$

The rest mass energy of electron = 0.511 MeV and 'c' is the velocity of light.

12. Which of the following statements is NOT CORRECT ?

- (A) The frequency of a Simple Harmonic Oscillator is independent of the amplitude
(B) The frequency of a Simple Harmonic Oscillator is directly proportional to the square of the amplitude
(C) The total energy of a Simple Harmonic Oscillator is directly proportional to the square of the amplitude
(D) The graph of potential energy of Simple Harmonic Oscillator with respect to position is a parabola

13. The condition that any vector \vec{A} should be the curl of any vector is :

- (A) $\vec{\nabla} \times \vec{A} = 0$ (B) $\vec{\nabla} \cdot \vec{A} = 0$
(C) $\vec{\nabla} \times \vec{A} - \vec{\nabla} \cdot \vec{A} = 0$ (D) $\nabla^2 \vec{A} = 0$

14. Which of the following statements is NOT CORRECT ?

- (A) Electrostatic field lines never can close upon themselves
(B) The divergence of the curl of any vector field is zero
(C) The curl of the gradient of any scalar field is zero
(D) If curl of any vector field is zero it is called solenoidal vector field

15. Which of the following represents the Gauss's law for a linear dielectric ?

- (A) $\vec{\nabla} \cdot \vec{E} = \frac{\rho_F}{\epsilon_0}$ (B) $\vec{\nabla} \cdot \vec{E} = \frac{\rho_F + \rho_B}{\epsilon}$
(C) $\vec{\nabla} \cdot \vec{E} = \frac{\rho_B}{\epsilon_0}$ (D) $\vec{\nabla} \cdot \vec{E} = \frac{\rho_F}{\epsilon}$

where ρ_F and ρ_B are volume charge densities of the free and the bound charges, ϵ is the permittivity of the linear dielectric and ϵ_0 is the permittivity of free space.

16. The time-averaged value of the Poynting vector for a plane polarized electromagnetic wave in free space is given by :

- (A) $\frac{1}{2} \epsilon_0 E^2$ (B) $\frac{1}{2} \epsilon_0 \mu_0 B^2$
(C) $\frac{1}{2} c \epsilon_0 E^2$ (D) $\frac{1}{2} \mu_0 B^2$

17. At frequencies above resonance frequency in an L - C - R series resonance circuit, the impedance of the circuit is :

- (A) inductive + resistive (B) capacitive + resistive
(C) mostly inductive (D) mostly capacitive

18. Which of the following statements is NOT CORRECT for an infinitely long cylindrical *solenoid* ?

- (A) Magnetic field inside the *solenoid* is uniform
(B) Magnetic field inside the *solenoid* is independent of the distance from the axis
(C) Magnetic field inside the *solenoid* is non-uniform
(D) Magnetic field outside the *solenoid* vanishes

19. Which of the following statements is NOT CORRECT ?

- (A) Maxwell's equations in free space are invariant under Lorentz transformation
(B) Maxwell's equations were able to explain the quantization of electric charges
(C) Maxwell's equation show that electromagnetic waves travel with the same speed in every inertial frame
(D) Maxwell's equations were able to unify the theories of electromagnetism and optics

20. James Maxwell found discrepancy in which of the following laws ?
- (A) Biot-Savart law
 - (B) Faraday's laws
 - (C) Ampere's circuital law
 - (D) All of the above from (A) to (C)
21. Which of the following statements is NOT CORRECT ?
- (A) For a collection of particles at thermal equilibrium at a temperature T , the average value of each quadratic contribution to the energy is the same and equal to $\frac{1}{2}kT$
 - (B) The law of equipartition of energy is applicable only when the effects of quantization are ignored
 - (C) The law of equipartition of energy is applicable for only classical statistical systems
 - (D) According to law of equipartition of energy, each degree of freedom has an average energy equal to $\frac{3}{2}kT$
22. Which of the following is the origin of van der Waals forces ?
- (A) Dipole - Dipole interaction
 - (B) Dipole - Induced dipole interaction
 - (C) Induced dipole-Induced dipole interaction
 - (D) All the above from (A) to (C)
23. The helium is the most difficult of all gases to liquify because :
- (A) at atmospheric pressure, it boils at approximately -196°C
 - (B) the attractive forces between helium atoms are very weak
 - (C) the attractive forces between helium atoms are strong
 - (D) the repulsive forces between helium atoms are very strong
24. For reversible processes, the entropy of the system is always :
- (A) Positive
 - (B) Negative
 - (C) Zero
 - (D) Constant

25. Which of the following is an intensive variable of a thermodynamical system ?
- (A) Entropy (B) Volume
(C) Mass (D) Pressure
26. If V_{RMS} , \bar{v} and V_p denote respectively the r.m.s. speed, average speed and most probable speed of molecules in a gas obeying Maxwell-Boltzmann distribution law for molecular speeds, then :
- (A) $V_{RMS} < \bar{v} < V_p$ (B) $\bar{v} < V_{RMS} < V_p$
(C) $V_p < \bar{v} < V_{RMS}$ (D) $V_{RMS} < V_p < \bar{v}$
27. If 'W' represents the number of microstates associated with a macrostate, the Entropy of the system is given by :
- (A) $S = k \ln W^2$ (B) $S = k \ln W$
(C) $S = \sqrt{k \ln W}$ (D) $S = (k \ln W)^2$
28. Four distinguishable particles are to be distributed into two exactly similar compartments in an open box. The total number of macrostates is equal to :
- (A) 5 (B) 4
(C) 6 (D) 1
29. To what tension must a string with mass 0.01 kg and length 2.5 m be tightened so that waves will travel on it at a speed of 125 m/s ?
- (A) 60.0 N (B) 65.0 N
(C) 62.5 N (D) 65.2 N
30. The Michelson interferometer is based on the interference :
- (A) by division of wavefront
(B) by division of amplitude
(C) by division of both wavefront and amplitude
(D) None of the above from (A) to (C)

31. The relation between *group velocity* v_g and *wave velocity* v_p in a dispersive medium is given by :

(A) $v_g = v_p - \lambda \frac{\partial v_p}{\partial \lambda}$

(B) $v_p = v_g - \lambda \frac{\partial v_g}{\partial \lambda}$

(C) $v_g = v_p + \lambda \frac{\partial v_p}{\partial \lambda}$

(D) $v_p = v_g + \lambda \frac{\partial v_g}{\partial \lambda}$

where λ is the wavelength.

32. The amplitude of the simple harmonic motion obtained by combining the motions

$y_1 = 2 \sin wt$, $y_2 = 2 \sin (wt + \frac{\pi}{3})$; is approximately :

(A) 4

(B) $\sqrt{3}$

(C) $\sqrt{3.5}$

(D) 3.5

33. The primary mirror of Hubble's Space Telescope is 2.4 m in diameter. Its resolving power for visible light of wavelength 600 nm is approximately :

(A) $\frac{1}{80,000}$ of a degree

(B) $\frac{1}{60,000}$ of a degree

(C) $\frac{1}{600,000}$ of a degree

(D) $\frac{1}{800,000}$ of a degree

34. The width of central maxima in the diffraction pattern due to a single narrow slit is :

(A) independent of slit width

(B) directly proportional to the slit width

(C) directly proportional to the square of slit width

(D) inversely proportional to slit width

35. Unpolarized light is incident on a polarizer. The ratio of maximum transmission to maximum incident intensity will be :

(A) $\frac{1}{8}$

(B) $\frac{1}{2}$

(C) $\frac{1}{4}$

(D) 1

36. Which of the following statements is NOT CORRECT ?

- (A) If the source of light is at a finite distance from the diffracting aperture, then the wavefronts falling on the aperture or reaching the screen will not be plane wavefronts
- (B) If the source of light or the observation screen or both of them are at finite distances from the diffracting aperture, then diffraction falls under the category of Fresnel type of Diffraction
- (C) If the source of light or the observation screen or both of them are at infinite distances from the diffracting aperture, then diffraction falls under the category of Fraunhofer type of Diffraction
- (D) If the source of light is at a finite distance from the diffracting aperture, then the wavefronts falling on the aperture or reaching the screen will be plane wavefronts

37. The de Broglie wavelength of an electron of kinetic energy K is proportional to :

- (A) K
- (B) \sqrt{K}
- (C) K^{-1}
- (D) $K^{-\frac{1}{2}}$

38. The quantum mechanical operator for the momentum of a particle moving in one dimension is given by :

- (A) $i\hbar \frac{d}{dx}$
- (B) $i\hbar \frac{\partial}{\partial t}$
- (C) $-i\hbar \frac{d}{dx}$
- (D) $-\frac{\hbar^2}{2m} \frac{d^2}{dx^2}$

39. Which of the following is NOT among the principles of quantum mechanics ?

- (A) Lorentz invariance
- (B) Angular-momentum quantization
- (C) Linear Superposition
- (D) Uncertainty principle

40. A non-monochromatic light is used in an experiment on photoelectric effect. The stopping potential :

- (A) is related to the mean wavelength
- (B) is related to the longest wavelength
- (C) is related to the shortest wavelength
- (D) is not related to the wavelength

41. The fine structure of atomic spectral lines arises due to :

- (A) electron spin-orbit coupling
- (B) interaction between electron and nucleus
- (C) nuclear spin
- (D) application of electric field to the atom

42. Which of the following statements is CORRECT ?

- (A) Electronic transitions involving valence electrons lie in the infra-red region
- (B) Vibrational transitions of molecules lie in the infra-red region
- (C) Transitions involving inner shell electrons lie in visible region
- (D) Electronic transitions involving valence electrons lie in the X-ray region

43. The dependence of the rotational energy of a diatomic molecule on the rotational quantum number J is given by :

- (A) $E = hc B J (J - 1)$
- (B) $E = hc B J (J + 1)$
- (C) $E = hc B J^2 (J + 1)^2$
- (D) $E = hc B J^2 (J - 1)^2$

where B is the rotational constant of the molecule.

44. Raman effect is based on the principle of :

- (A) Inelastic scattering of a photon by another photon
- (B) Elastic scattering of a photon by another photon
- (C) Inelastic scattering of a photon by a molecule
- (D) Elastic scattering of a photon by a molecule

45. What is the main drawback of liquid drop model of nucleus ?

- (A) It is not successful in describing the low lying excited states
- (B) It is not able to explain nuclear fission
- (C) It is not able to predict binding energy of large number of nuclei
- (D) It is not able to predict α and β -emissions properly

46. In a *Nuclear Reactor* the coolants are used :
- (A) to absorb neutrons
 - (B) to slow down neutrons
 - (C) to remove heat from reactor core
 - (D) to control the fission process in the reactor
47. The saturation property of nuclear forces means that :
- (A) Each nucleon interacts only with immediate neighbouring nucleons in the nucleus
 - (B) Each nucleon interacts very weakly with its immediate neighbours
 - (C) Nuclear force has a constant value as a function of nuclear radius
 - (D) Each nucleon interacts with a constant force with the neighbouring nucleons in the nucleus
48. Which of the following are NOT Elementary particles ?
- (A) Leptons
 - (B) Quarks
 - (C) Photons
 - (D) Pions
49. The dispersion relation for a one dimensional monatomic crystal with lattice spacing a , which interacts via nearest neighbour harmonic potential is given by :
- (A) $\omega = A \left| \sin \frac{Ka}{2} \right|$
 - (B) $\omega = A |\sin Ka|$
 - (C) $\omega = A \left| \sin^2 \frac{Ka}{2} \right|$
 - (D) $\omega = A |\sin^2 Ka|$
- where A is a constant of appropriate units.
50. The Laue method of X-ray diffraction by a crystal is suitable for determination of :
- (A) Complete crystal structure
 - (B) Crystal orientation and symmetry
 - (C) Surface structure and crystal imperfections
 - (D) Lattice parameters
51. At lower temperatures, the lattice specific heat varies as :
- (A) T^3
 - (B) T^2
 - (C) T^{-1}
 - (D) T

52. For an ideal Fermi *electron gas* in three dimensions, the electron velocity V_F at the Fermi surface is related to electron concentration, n , as
- (A) $V_F \propto n^{\frac{2}{3}}$ (B) $V_F \propto n^{\frac{1}{3}}$
- (C) $V_F \propto n^{\frac{1}{2}}$ (D) $V_F \propto n$
53. In the Kronig-Penny model, electrons are assumed to be moving in :
- (A) One dimensional square-well potential
 (B) One dimensional square-well periodic potential
 (C) One dimensional periodic harmonic potential
 (D) Three dimensional Coulomb potential
54. The principle of working of a 'Tunnel Diode' can be explained on the basis of :
- (A) Classical Electromagnetic Theory
 (B) Quantum Mechanics
 (C) Classical Mechanics
 (D) None of the above from (A) to (C)
55. Which of the following statements is NOT CORRECT regarding a *p-n junction* ?
- (A) New holes and conduction electrons are produced continuously throughout the material
 (B) New holes and conduction electrons are produced continuously throughout the material except in the depletion region
 (C) Holes and conduction electrons recombine continuously throughout the material except in the depletion region
 (D) All the above are NOT CORRECT
56. The main disadvantage of JFET over BJT is due to its :
- (A) Low input impedance
 (B) Negative temperature coefficient of resistance
 (C) Low gain-bandwidth product
 (D) High gain-bandwidth product

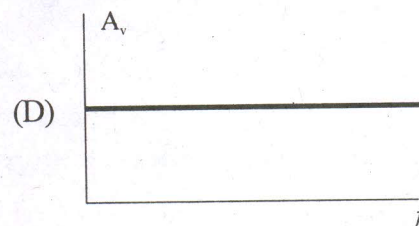
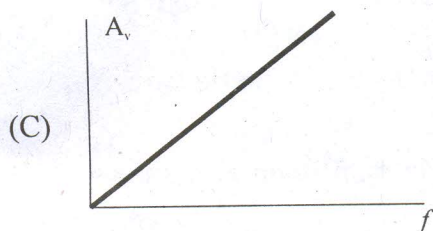
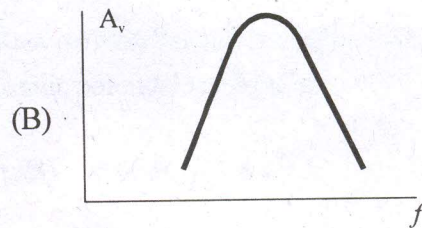
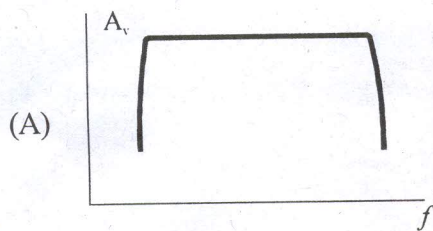
57. In a common emitter amplifier, the voltage gain depends mainly on :

- (A) h_{fe} and h_{re}
- (B) h_{fe} and h_{ie}
- (C) h_{fe} and h_{oe}
- (D) h_{re} and h_{ie}

58. Which of the following statements is NOT CORRECT regarding a Zener diode ?

- (A) It is reverse biased properly doped crystal diode having a sharp breakdown voltage
- (B) The breakdown voltage, called the *Zener voltage*, depends upon the amount of doping
- (C) If a Zener diode is heavily doped the Zener voltage is low
- (D) When a Zener diode is operated in the forward bias region, the voltage across it remains practically constant for a large change in the current

59. Which of the following curves nearly represent the frequency response of an RC coupled amplifier ?



60. Which of the following statements is CORRECT ?

- (A) An emitter follower has a high input impedance and a low output impedance
- (B) An emitter follower has a low input impedance and a low output impedance
- (C) An emitter follower has a low input impedance and a high output impedance
- (D) An emitter follower cannot be used for impedance matching.

7. The composition of two simple harmonic motions of equal period at right angle to each other and with a phase difference of π results in the displacement of the particle along:
- (A) circle (B) figure of 8
(C) straight line (D) ellipse
8. The angular velocity and the amplitude of a simple pendulum is ω and 'a' respectively. At a displacement 'x' from the mean position if its kinetic energy is 'T' and potential energy is 'V' then the ratio of T to V is :
- (A) $\frac{(a^2 - x^2)\omega^2}{x^2\omega^2}$ (B) $\frac{x^2\omega^2}{(a^2 - x^2\omega^2)}$
(C) $\frac{(a^2 - x^2)}{x^2}$ (D) $\frac{x^2}{(a^2 - x^2)}$
9. Two vibrating tuning forks produce waves given by $y_1 = 4\sin(500\pi t)$ and $y_2 = 2\sin(506\pi t)$, where t is in seconds. Number of beats produced per min is :
- (A) 360 (B) 180
(C) 60 (D) 3
10. The time of reverberation of a room A is 1 s. What will be the time (in seconds) of reverberation of a room, having all the dimensions double of those of room A ?
- (A) 1 (B) 2
(C) 4 (D) 1/2
11. A transverse wave propagation along X-axis is represented by $y(x, t) = 8.0 \sin(0.5\pi x - 4\pi t - \frac{\pi}{4})$ where x is in meters and t is in seconds. The speed of the wave is:
- (A) 8 ms^{-1} (B) $4 \pi \text{ ms}^{-1}$
(C) $0.5 \pi \text{ ms}^{-1}$ (D) $\frac{\pi}{4} \text{ ms}^{-1}$

12. Which one of the following statements is true ?
- (A) Both light and sound waves can travel in vacuum
 - (B) Both light and sound waves in air are transverse
 - (C) The sound waves in air are longitudinal while the light waves are transverse
 - (D) Both light and sound waves in air are longitudinal
13. An electrons beam has kinetic energy equal to 100 eV. Find wavelength associated with the beam, if mass of electron = $9.1 \times 10^{-31} \text{ kg}$:
- (A) 24.6 Å
 - (B) 0.12 Å
 - (C) 1.2 Å
 - (D) 6.3 Å
14. The kinetic energy of an electron, which is accelerated in the potential difference of 100 V, is :
- (A) 416.6 cal
 - (B) 6.636 cal
 - (C) $1.602 \times 10^{-17} \text{ J}$
 - (D) $1.6 \times 10^4 \text{ J}$
15. The momentum of a photon of energy 1 MeV in kg m/s will be :
- (A) 5×10^{-22}
 - (B) 0.33×10^{-6}
 - (C) 7×10^{-24}
 - (D) 10^{-22}
16. A beam of electron passes undeflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off, and the same magnetic field is maintained, the electrons move :
- (A) In a circular orbit
 - (B) Along a parabolic path
 - (C) Along a straight line
 - (D) In an elliptical orbit
17. Monochromatic light of frequency $6.0 \times 10^{14} \text{ Hz}$ is provided by a laser. The power emitted on the average is $2 \times 10^{-3} \text{ W}$. The number of photons emitted, on the average, by the source per second is :
- (A) 5×10^{16}
 - (B) 5×10^{17}
 - (C) 5×10^{14}
 - (D) 5×10^{15}

18. The ionization energy of hydrogen atom is 13.6 eV. Following Bohr's theory, the energy corresponding to a transition between 3rd and 4th orbit is :
- (A) 3.40 eV (B) 1.51 eV
(C) 0.85 eV (D) 0.66 eV
19. The energy equivalent of one atomic mass unit is :
- (A) $1.6 \times 10^{19} J$ (B) $6.02 \times 10^{23} J$
(C) 931 meV (D) 9.31 MeV
20. The mass of the α particle is :
- (A) Less than the sum of the masses of two protons and two neutrons
(B) Equal to mass of four protons
(C) Equal to mass of four neutrons
(D) Equal to sum of the masses of two protons and two neutrons
21. The mass density of a nucleus varies with mass number A as :
- (A) A^2 (B) A
(C) *Constant* (D) $1/A$
22. Special theory of relativity states that :
- (A) Mass remains unaffected in any inertial frame
(B) Velocity of light remains unaffected in any inertial frame
(C) Momentum conservation is not valid at high speed
(D) Time remains same in all inertial frames
23. At what velocity must a particle move so that its kinetic energy is equal to its rest energy ?
- (A) $\frac{\sqrt{3}c}{4}$ (B) $\frac{\sqrt{3}c}{2}$
(C) $\frac{2c}{\sqrt{3}}$ (D) $\frac{2\sqrt{2}c}{3}$

24. A particle and its antiparticle are annihilated in a nuclear reaction. The amount of energy released is :

- (A) Zero (B) $\frac{1}{2}mc^2$
(C) mc^2 (D) $2mc^2$

25. When a given amount of water is heated from 0°C to 100°C , its mass :

- (A) Remains unchanged (B) Decreases slightly
(C) Increases slightly (D) Increases substantially

26. Which of the following particle parameters remains unchanged even at relativistic speeds ?

- (A) charge (B) mass
(C) linear dimensions (D) charge to mass ratio

27. If a p-n junction is reverse biased, then resistance measured by ohm-meter, will be :

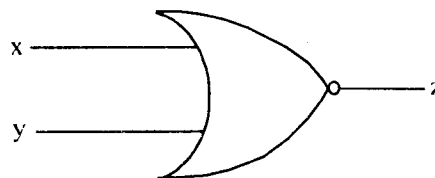
- (A) infinite (B) high
(C) low (D) zero

28. The truth table given here is valid for which of the following gates ?

X	Y	Output
0	0	0
1	0	1
0	1	1
1	1	1

- (A) NAND (B) OR
(C) AND (D) NOT

29. The symbol represents :



- (A) NOR gate (B) OR gate
(C) AND gate (D) NAND gate

30. Depletion layer consists of :
- (A) electrons (B) protons
(C) mobile charge carriers (D) immobile ions
31. The expansion of galaxies is supported by :
- (A) neutron stars (B) white dwarf
(C) red shift (D) blue shift
32. In high energy physics, the worlds largest experimental facility LHC stands for :
- (A) Large heavy collisions
(B) Large hyper-particle collider
(C) Large hadron collider
(D) Large hydrogen collider
33. Which of the following are suitable for the fusion process ?
- (A) light nuclei
(B) heavy nuclei
(C) elements lying in the middle of the periodic table
(D) highly unstable nuclei
34. The volume occupied by an atom is greater than the volume of the nucleus by a factor of :
- (A) 10^1 (B) 10^5
(C) 10^{10} (D) 10^{15}
35. Due to earths magnetic field, the charged cosmic ray particles :
- (A) can never reach the pole
(B) can never reach the equator
(C) require greater kinetic energy to reach the equator than the pole
(D) require less kinetic energy to reach the equator than the pole
36. Center of mass of system of particles does not depend on :
- (A) Position of particles
(B) relative distance between the particles
(C) masses of the particles
(D) forces acting on the particles

37. Moment of inertia of a uniform circular disc about a diameter is I . Its moment of inertia about an axis perpendicular to its plane and passing through a point on its rim will be :
- (A) $5I$ (B) $6I$
(C) $4I$ (D) $3I$
38. Two bodies of masses m and $4m$ are moving with equal kinetic energy. The ratio of their linear momenta is :
- (A) $1 : 2$ (B) $2 : 1$
(C) $1 : 4$ (D) $4 : 1$
39. The part of transistor which is heavily doped to produce large number of majority carriers is :
- (A) emitter
(B) base
(C) collector
(D) any one of these depending upon the nature of the transistor
40. When arsenic is added to an impurity to silicon, the resulting material is :
- (A) n-type conductor
(B) n-type semiconductor
(C) p-type semiconductor
(D) p-type conductor
41. In considering motion of an object under the gravitational influence of another object, which of the following quantities is not conserved ?
- (A) Angular momentum (B) Total energy
(C) Linear momentum (D) Mass of the object
42. A particle is projected with kinetic energy K at an angle of 60° with the horizontal, the kinetic energy at top of its trajectory is :
- (A) $K/4$ (B) $K/2$
(C) K (D) $2K$

43. Infinite number of bodies each of mass 6 kg, are situated at distances 1 m, 2 m, 4 m, 8 m, respectively from the origin. The resultant gravitational field intensity at the origin is:
- (A) 4 G (B) 3 G
(C) 8 G (D) Infinity
44. If a satellite is suddenly stopped in its orbit and allowed to fall freely to earth, the speed with which it hits the earth is :
- (A) \sqrt{gR} (B) $\sqrt{2gR}$
(C) $\sqrt{3gR}$ (D) $2\sqrt{gR}$
45. Two sources of intensity I and 4I are used in the interference experiment. The intensity at a point where the waves from the two sources superimpose with a phase difference of $\frac{\pi}{2}$ is :
- (A) 0 (B) 2I
(C) 3I (D) 5I
46. The penetration of light into the region of geometrical shadow is called :
- (A) Polarization (B) Interference
(C) Diffraction (D) Dispersion
47. A particle moves in a straight line with retardation proportional to displacement. Its loss of kinetic energy for any displacement 'x' is proportional to :
- (A) x^2 (B) e^x
(C) x (D) $\log_e x$
48. A bomb of mass 16 kg at rest explodes into two pieces of mass 4 kg and 12 kg. The velocity of 12 kg mass is 4 ms^{-1} . The kinetic energy of the other mass is :
- (A) 96 J (B) 144 J
(C) 288 J (D) 192 J

49. Moment of inertia of a rod of mass M , length l about an axis perpendicular to it through a point $\frac{l}{4}$ from one end is :
- (A) $\frac{Ml^2}{12}$ (B) $\frac{7}{48}Ml^2$
 (C) $\frac{3}{24}Ml^2$ (D) $\frac{5}{36}Ml^2$
50. Two identical metal balls with charges $+2Q$ and $-Q$ are separated by some distance, and exert a force 'F' on each other. They are joined by a conducting wire, which is then removed. The force between them will now be :
- (A) $\frac{F}{1}$ (B) $\frac{F}{2}$
 (C) $\frac{F}{4}$ (D) $\frac{F}{8}$
51. Which of the following electromagnetic radiations have the longest wavelength ?
- (A) X-rays (B) γ -rays
 (C) Microwaves (D) Radio waves
52. In which of the following, emission of electrons does not take place ?
- (A) Thermionic emission (B) X-rays emission
 (C) Photoelectric effect (D) Secondary emission
53. The frequency of electromagnetic wave, best suited to observe a particle of radius 3×10^{-4} cm is of the order of :
- (A) 10^{15} (B) 10^{14}
 (C) 10^{13} (D) 10^{12}
54. The structure of solids is investigated by using :
- (A) Cosmic rays (B) X-rays
 (C) γ -rays (D) Infra-red radiations

55. A signal emitted by an antenna from a certain point can be received at another point of the surface in the form of :
- (A) Sky Wave (B) Ground Wave
(C) Sea Wave (D) Both (A) and (B)
56. The velocity of electromagnetic wave is parallel to :
- (A) $B \times E$ (B) $E \times B$
(C) E (D) B
57. According to kinetic theory of gases, at absolute zero of temperature :
- (A) water freezes (B) liquid helium freezes
(C) molecular motion stops (D) liquid hydrogen freezes
58. Relation between pressure (P) and energy (E) of a gas is :
- (A) $P = \frac{2}{3}E$ (B) $P = \frac{1}{3}E$
(C) $P = E$ (D) $P = 3E$
59. The number of translational degrees of freedom for a diatomic gas is :
- (A) 2 (B) 3
(C) 5 (D) 6
60. An ideal gas A and a real gas B have their volumes increased from V to 2V under isothermal conditions. The increase in internal energy :
- (A) will be same in both A and B
(B) will be zero in both the gases
(C) of B will be more than that of A
(D) of A will be more than that of B

1. Ideal inertial frame of reference is
- System attached to the earth
 - System referred to the fixed stars
 - System that is acted upon by zero net force
 - Uniformly moving aircraft
2. Electromagnetic Maxwell's equations are invariant under :
- Galilean transformation
 - Lorentz transformation
 - Both Galilean and Lorentz transformation
 - None of (a) to (c)
3. What is the correct relativistic transformation for the y-component of velocity (relative velocity along x-direction) ?
- $V'_y = \frac{V_y \sqrt{(1-v^2/c^2)}}{(1-vV_x/c^2)}$
 - $V'_y = \frac{V_y \sqrt{(1-v^2/c^2)}}{(1-vV_y/c^2)}$
 - $V'_y = \frac{V_y - v}{(1-vV_x/c^2)}$
 - $V'_y = V_y$
4. In the twin paradox, suppose that twin (A) takes off in one direction while twin (B) travels at the same speed but in the opposite direction. They travel an equal distance from Earth, then turn around and come back. What will twins and the Earth's clocks show ?
- Twins clocks will show same time and this time will be less than the elapsed time on the earth
 - Twins clocks will show same time and this time will be greater than the elapsed time on the earth
 - Twins clocks will show different times and one twin clock will show same time as on the earth based clock
 - All the three clocks will show different times
5. An orbiting space station is observed to remain always vertically above the same point on the earth. Where on earth is the observer ?
- On the North Pole
 - On the South Pole
 - In Pacific Ocean
 - On the Equator

6. The average orbital distance of Mars is 1.52 times the average orbital distance of the Earth. Knowing that the Earth orbits the Sun in approximately 365 days, the calculated time for Mars to orbit the sun is :
- (a) 365 days (b) 100 days
(c) 200 days (d) 684 days
7. A hunter holds a 3 kilogram rifle loosely in his hands and fires a bullet of mass 5 gram with the muzzle velocity of 300 meters/sec. What is the recoil velocity of the rifle ?
- (a) 0.5 meters/sec (b) -0.5 meters/sec
(c) Zero (d) 10 meters/sec
8. Suppose a shell traveling in a parabolic trajectory explodes in flight, splitting into two fragments of equal mass. Which of the following statement is correct for the onward motion of this system ?
- (a) Two fragments will follow the centre of mass trajectory
(b) Two fragments and centre of mass will all follow different trajectories from the original parabolic trajectory
(c) Centre of mass of the fragments will continue on the original trajectory
(d) None of (a) to (c)
9. Why rubber material is considered valuable as vibration absorber ?
- (a) Because it obeys Hook's law of elasticity
(b) Because it breaks only when stretched four times its original length
(c) Because it has elastic hysteresis
(d) None of (a) to (c)
10. In the spring-mass system obeying a simple harmonic motion, which of the following quantity remains constant for varying initial displacements :
- (a) Frequency (b) Maximum speed
(c) Maximum displacement (d) Maximum acceleration
11. Why do ocean waves slow down as they approach the shore ?
- (a) Depth is much greater than the wavelength of the wave
(b) Depth is much lower than the wavelength of the wave
(c) Depth is comparable to the wavelength of the wave
(d) None of (a) to (c)

12. In the Lissajous figures, which of the following statement is incorrect ?
- When two sine waves are of equal frequency and in-phase, a diagonal line to the right is produced
 - When two sine waves are of equal frequency and 180° out of phase, a diagonal line to the left is produced
 - When two sine waves are of equal frequency and 90° out of phase, a circle is produced
 - When two sine waves are of equal frequency and out of phase, a diagonal line to the right is produced
13. Which of the following statement is incorrect in the forced harmonic oscillator problem ?
- In the damped case, the steady state behavior depend on the initial conditions
 - In the undamped case, beats occur when the forcing frequency is close to (but not equal to) the natural frequency of the oscillator
 - The second order linear harmonic oscillator (damped or undamped) with sinusoidal forcing can be solved by using the method of undetermined coefficients
 - In the undamped case, resonance occurs when the forcing frequency is the same as the natural frequency of the oscillator
14. If $\vec{A} = \frac{1}{2}(\vec{B} \times \vec{\gamma})$, then $\nabla \times \vec{A}$ equal to :
- Zero
 - \vec{A}
 - \vec{B}
 - $\vec{B}/2$
15. If $\vec{B} = \nabla \times \vec{A}$, the value of the surface integral $\iint \vec{B} \cdot d\sigma$ (integral is over a closed surface) is equal to :
- Infinity
 - Zero
 - \vec{A}
 - None of (a) to (c)
16. Which of the following statement is correct in the multipole expansion of the electric field ?
- Dipole moment changes on shifting the origin if the net charge is zero
 - Point charge at the origin has both monopole and dipole moment
 - Point charge away from the origin has only monopole moment
 - Dipole moment does not change on shifting the origin if the net charge is zero

17. The reason that there is no potential corresponding to electric displacement (\vec{D}) like there is one for electric field (\vec{E}) is :

- (a) $\nabla \times \vec{D}$ is not equal to zero (b) $\nabla \times \vec{D}$ is equal to zero
(c) Gauss law for \vec{D} does not exist (d) None of (a) to (c)

18. Which of the following statement is incorrect for a solenoid ?

- (a) Magnetic field inside the solenoid is uniform
(b) Magnetic field outside the solenoid is independent of the distance from the axis
(c) Magnetic field inside the solenoid is non-uniform
(d) Magnetic field outside the solenoid vanishes

19. Maxwell's equations don't include the following observed phenomenon :

- (a) Conservation of electric charge
(b) Quantization of charge
(c) Electric and magnetic fields are perpendicular to each other
(d) Velocity of light is equal to c in all inertial frames

20. In the case of monochromatic plane electromagnetic wave, we have :

- (a) $\vec{B} = \frac{1}{c^2} \vec{E}$ (b) $E B = \text{constant}$
(c) $E^2 = \frac{1}{c^2} B^2$ (d) $B^2 = \frac{1}{c^2} E^2$

21. Using Equipartition theorem, total average kinetic energy of a di-atomic molecule is:

- (a) $\frac{5}{2} kT$ (b) $\frac{3}{2} kT$
(c) $\frac{1}{2} kT$ (d) $\frac{7}{2} kT$

22. Which of the following is not true for the van-der-Waals gas equation,

$$\left(P + \frac{a}{V^2} \right) (V - b) = RT;$$

- (a) It can be derived by assuming that each molecule moves in an effective potential generated by other molecules
(b) Reduces to the ideal gas equation for $V \rightarrow \infty$
(c) It can be applied to very low density gas only
(d) a/V^2 is due to long range attractive forces and b is due to repulsion

23. Which method is suited to obtain temperatures below one Kelvin ?
- (a) Helium dilution refrigerator (b) Magnetic cooling
(c) Laser cooling (d) All of (a) to (c)
24. The amount of heat that is absorbed by unit mass of a substance during change of state is known as :
- (a) Specific heat (b) Latent heat
(c) Coefficient of linear expansion (d) Thermal capacity
25. One kilogram of ice at 0°C is melted and converted to water at 0°C . What is the change in entropy ?
- (a) 1 Joule/Kelvin (b) 1223 Joule/Kelvin
(c) Zero (d) 334×10^3 Joule/Kelvin
26. The average value of the average energy (\bar{E}) is equal to :
- (a) \bar{E} (b) Zero
(c) E (d) $E \bar{E}$
27. Suppose you have a gas in a cylinder with a piston and you hit the piston very hard, so that it moves inward much faster than the gas molecules inside. Let us then assume that piston stops after moving a very small distance and the pressure has increased only infinitesimally. The increase in entropy is then :
- (a) Greater than Q/T (b) Equal to Q/T
(c) Zero (d) 6060 Joule/Kelvin
28. Which of the following assumption is not necessary in the derivation of Boltzmann distribution :
- (a) All states are equally probable
(b) System is in thermal contact with a heat bath
(c) System and the heat bath are of equal size
(d) Energy of the heat bath is constant
29. Maxwell velocity distribution has :
- (a) Parabolic shape for all velocities
(b) Parabolic shape at lower velocities and exponentially decaying shape at large velocities
(c) Gaussian shape for all velocities
(d) Linear shape for all velocities

30. The pressure amplitude of a sound wave depends on :
- Displacement amplitude
 - Wavelength of the sound wave
 - Bulk modulus of the material through which sound is propagating
 - All of (a) to (c)
31. In which of the following wave, polarization phenomenon is not possible ?
- Longitudinal wave
 - Transverse wave
 - X-rays
 - Gamma-rays
32. The lens aberration is not due to :
- Nonparaxial nature of the rays from the object
 - Variation of the Index of the refraction with wavelength
 - Faulty construction of the lens
 - Finite size of the lens
33. What is the advantage of the diffraction grating in spectrometry ?
- Velocity of the light can be measured
 - Wavelength of the light can be computed
 - Refractive index of the medium can be computed
 - All of (a) to (c)
34. The output of a laser has a pulse width of $30 \times 10^{-3} \text{ sec}$ and average output power of 0.6 watt. If the wavelength of the laser light is 640 nm, how many photons does each pulse approximately contain ?
- 10^{16}
 - 10^{10}
 - 10^2
 - 10
35. In Young's experiment, two slits are spaced 0.2mm apart and a screen at a distance of 1m, the third bright fringe is found to be displaced 7.5mm from the central fringe. The wavelength of the light used is :
- $500 \times 10^{-6} \text{ m}$
 - $500 \times 10^{-3} \text{ m}$
 - $500 \times 10^{-9} \text{ m}$
 - $500 \times 10^{-9} \text{ m}$
36. Which are the two fundamental principles of quantum mechanics ?
- Lorentz invariance and Bohr quantization
 - Energy and angular-momentum quantization
 - Linear Superposition and Uncertainty
 - Measurement process and Pauli exclusion

37. A proton and an α particle have the same kinetic energy. If the mass of the α particle is four times that of a proton, how do their de Broglie wavelengths compare ?
- (a) $\lambda_p = \lambda_\alpha/4$ (b) $\lambda_p = \lambda_\alpha/2$
(c) $\lambda_p = \lambda_\alpha$ (d) $\lambda_p = 2 \lambda_\alpha$
38. For a one-dimensional motion, time-independent Schrodinger equation predicts the following general result, independent of the form of the potential :
- (a) Eigen values are non-degenerate
(b) Eigen values are degenerate
(c) Energy is always discrete
(d) Wavefunction is always a plane wave
39. In the Schrodinger Hydrogen atom problem, the occurrence of integral values for n and l quantum numbers emerge on imposing :
- (a) Uncertainty principle
(b) Pauli exclusion principle
(c) Bohr quantization condition
(d) Boundary conditions at origin and infinity
40. If the uncertainty in the location of a particle is equal to its de Broglie wavelength, minimum uncertainty in its velocity is :
- (a) Zero (b) 10 times its velocity
(c) Equal to its velocity (d) 100 times its velocity
41. Which of the following inequality is true in quantum mechanics (E_n is the energy eigenvalue and U_{min} is the minimum of the potential) ?
- (a) $E_n > U_{min}$ (b) $E_n \geq U_{min}$
(c) $E_n < U_{min}$ (d) $E_n \leq U_{min}$
42. The probability of finding the electron in the $1s$ state in hydrogen atom is maximum when radial distance is :
- (a) Half of the Bohr distance (b) Twice of Bohr radius
(c) Equal to Bohr radius (d) None of (a) to (c)
43. The electronic configuration of ^{22}Ti is :
- (a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$ (b) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4p^2$
(c) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^2$ (d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$

44. Spin-orbit interaction in atomic phenomena :
- (a) Increases with atomic number
 - (b) Decreases with atomic number
 - (c) Remains constant with atomic number
 - (d) None of (a) to (c)
45. The reason that states of Sodium atom with smaller orbital angular momentum (l) are lower in energy as compared to the corresponding states in the hydrogen atom is :
- (a) States with lower l are more shielded from the nuclear charge
 - (b) States with lower l are less shielded from the nuclear charge
 - (c) The last electron in the two atoms are in different l states
 - (d) None of (a) to (c)
46. Which of the following statement is correct regarding molecular spectra ?
- (a) Both electronic transitions and rotational spectra lie in extreme infrared and microwave regions
 - (b) Both electronic transitions and rotational spectra lie in visible or ultraviolet regions
 - (c) Electronic transitions lie in visible or ultraviolet regions and rotational spectra lie in extreme infrared and microwave regions
 - (d) None of (a) to (c)
- ✓ 47. In radioactive nuclear decay, the reason that α -particle is emitted and not a proton is due to :
- (a) Proton is a positively charged particle
 - (b) Low binding energy of the α -particle
 - (c) Proton spin
 - (d) High binding energy of the α -particle
48. What is the meaning of the saturation property of the nuclear force ?
- (a) Each nucleon interacts only with immediate neighboring nucleons in the nucleus
 - (b) Each nucleon interacts with a constant force with the neighboring nucleons in the nucleus
 - (c) Nuclear force has a constant value as a function of nuclear radius
 - (d) Each nucleon interacts very weakly with immediate neighbors

49. The ionization power of α particle is :
- 100 times smaller than that of β particle
 - 100 times greater than that of β particle
 - Equal to that of β particle
 - 1000 times less than that of β particle
50. The major difference between electron and positron spectra in β -decay is :
- Many low energy electrons and very few low energy positrons
 - Many high energy electrons and very few high energy positrons
 - Electron spectrum is peaked and positron spectrum is not peaked
 - None of (a) to (c)
51. If r is the radius of the atom, the number of atoms per unit area of the plane (100) of a simple cubic crystal is :
- $4r^2$
 - $\frac{1}{4r}$
 - $\frac{1}{4r^2}$
 - None of (a) to (c)
52. In ferromagnetism :
- Number of electrons with opposite spin are equal
 - Number of electrons with opposite spin are zero
 - There is no magnetic moment
 - Number of electrons with opposite spin are unequal
53. The Free electron model of metals fails to explain the following property :
- Distinction between metals, semimetals and conductors
 - Occurrence of positive values of the Hall coefficient
 - Relation of conduction electrons in the metal to the valence electrons of free atoms
 - All of (a) to (c)
54. Which of the following statement is incorrect ?
- Alkaline earth elements have two valence electrons per primitive cell, but the bands overlap in energy and, therefore, are metals
 - Alkaline earth elements have two valence electrons per primitive cell and are insulators
 - Alkali metals have one valence electron per primitive cell, so that they have to be metals
 - Noble metals have one valence electron per primitive cell, so that they have to be metals

55. The smaller number of carriers and high mobility in semiconductors gives :
- | | |
|----------------------|------------------------|
| (a) Small Hall field | (b) Large Hall field |
| (c) Small Hall angle | (d) None of (a) to (c) |
56. Which of the following statement is wrong about a junction transistor ?
- | |
|--|
| (a) Area of the base collector junction is larger than that of the base emitter junction |
| (b) Base is very thin and is heavily doped |
| (c) Electron hole recombination taking place at the base is very small |
| (d) Doping of the collector is less than that of the emitter |
57. An increase of temperature of a semiconductor decreases :
- | | |
|-----------------|-------------------------------|
| (a) Band gap | (b) Conductivity |
| (c) Resistivity | (d) Size of the semiconductor |
58. Two resistances of $400\ \Omega$ and $800\ \Omega$ are connected in series with $6\ \text{volt}$ battery. To measure the current in the circuit, an ammeter of $10\ \Omega$ resistance is used. The reading in the ammeter is :
- | | |
|-----------------------|-----------------------|
| (a) $2.6\ \text{mA}$ | (b) $1.92\ \text{mA}$ |
| (c) $5.96\ \text{mA}$ | (d) $4.96\ \text{mA}$ |
59. Which of the following statement is correct for JFET (V_{GS} and V_p are the gate-source and pinch-off voltages) ?
- | |
|--|
| (a) In n-channel JFET both V_{GS} and V_p are negative |
| (b) In p-channel JFET both V_{GS} and V_p are positive |
| (c) Transfer characteristics in both types follow the same formula |
| (d) All of (a) to (c) |
60. In an AC series circuit :
- | |
|--|
| (a) Instantaneous voltage differences add algebraically and voltage amplitudes add vectorially |
| (b) Both instantaneous voltage differences and voltage amplitudes add algebraically |
| (c) Both instantaneous voltage differences and voltage amplitudes add vectorially |
| (d) None of (a) to (c) |

Physics - 2010

M.Sc. Physics

- An object, initially at rest, explodes into three pieces which move off in the x - y plane. Two of the pieces have mass m and are ejected perpendicular to each other with a speed v . The third piece, of mass $3m$, has speed
 - $2v/\sqrt{3}$
 - $\sqrt{2}v/3$
 - $\sqrt{2/3}v$
 - $\sqrt{3/2}v$
- The mass of a hypothetical planet is $1/100$ that of Earth and its radius is $1/4$ that of Earth. If a person weighs 75 N on Earth, what would he weigh on this planet?
 - 75 N
 - 24 N
 - 12 N
 - 6 N
- The flow of a liquid is said to be turbulent if its Reynold number is more than :
 - 3
 - 30
 - 300
 - 3000
- Bernoulli's equation applies to :
 - An incompressible fluid, not necessarily viscous
 - A static fluid only
 - An incompressible, nonviscous, nonturbulent fluid
 - An incompressible, viscous, and nonturbulent fluid
- Which of the following statements is not completely correct about stationary waves ?
 - Stationary waves are formed by the superposition of two wave trains of the same frequency and amplitude travelling in opposite directions.
 - Stationary waves can be transverse or longitudinal
 - In longitudinal stationary waves, antinodes are the points where there is no pressure or density change
 - Stationary waves do not advance but there is net transfer of energy.
- Two simple pendulums, A and B, have the same length, but the mass of A is twice the mass of B. Their vibrational amplitudes are equal. Their periods are T_A and T_B respectively and their energies are E_A and E_B . Choose the correct statement :
 - $T_A = T_B$ and $E_A > E_B$
 - $T_A < T_B$ and $E_A > E_B$
 - $T_A > T_B$ and $E_A < E_B$
 - $T_A = T_B$ and $E_A < E_B$

7. An inertial frame is a frame in which :
- there are no forces
 - there are no accelerations without applied forces
 - relativistic mechanics holds good but the Newtonian mechanics does not
 - relativistic mechanics does not hold good but the Newtonian mechanics does
8. A stationary body explodes into two fragments each of mass 1 Kg that move apart at speeds of $0.8c$ relative to the original body. The rest mass of the original body is :
- 3.3 Kg
 - 4.4 Kg
 - 2.5 Kg
 - 2.0 Kg
9. An astronaut in a rocket passes a metre stick moving parallel to its long dimension. The astronaut measures the metre stick to be 0.80 m long. How fast is the rocket moving with respect to the metre stick ?
- 0.4 C
 - 0.6 C
 - 0.8 C
 - 0.9 C
10. Three identical particles travel with the velocities indicated in the following options. Which has the greatest kinetic energy ?
- $v = 4i + 3j$
 - $v = -4i + 3j$
 - $v = 5i$
 - they are all the same
11. The value of a for which the vector $xi + 2yj + azk$ is solenoidal is :
- 1
 - 3
 - 1
 - None of the above
12. Curl of the curl of a vector V [i.e. $\nabla \times (\nabla \times V)$] equals :
- $\nabla (\nabla \cdot V) - \nabla^2 V$
 - $\nabla (\nabla \cdot V) + \nabla^2 V$
 - $\nabla^2 V - \nabla (\nabla \cdot V)$
 - 0
13. Two charged particles attract each other with a force of magnitude F acting on each. If the charge of both the particles is doubled and the distance separating the particles is also doubled, the force acting on each of the particles has the magnitude :
- F
 - $2F$
 - $F/2$
 - $F/4$

14. A capacitor stores charge Q at a potential difference V . If the voltage applied by a battery to the capacitor is doubled to $2V$:
- The capacitance falls to half of its initial value and the charge remains the same
 - The charge doubles and the capacitance remains the same
 - The capacitance and the charge both fall to half of their initial value
 - The capacitance and the charge both double
15. Impedance Z offered by an ac circuit containing resistance R , inductance L , and capacitance C is given by :
- $Z = \sqrt{R^2 + \left(L\omega + \frac{1}{C\omega}\right)^2}$
 - $Z = \sqrt{R^2 - \left(L\omega + \frac{1}{C\omega}\right)^2}$
 - $Z = \sqrt{R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2}$
 - $Z = \sqrt{R^2 + (L\omega)^2 + (C\omega)^2}$
16. An LC circuit oscillates with a period T for a capacitance C and an inductance L . If the capacitance is changed to $C/8$ and the value of the inductance is halved to $L/2$, what is the new period of oscillation ?
- $T/16$
 - $T/4$
 - $T/2$
 - $2T$
17. A particle with mass m and charge q moving with a velocity v perpendicular to a uniform magnetic field B follows a circular path of radius :
- mv/qB
 - qB/mv
 - qm/Bv
 - mB/qv
18. The magnitude of the induced emf in a circuit equals the time rate of change of magnetic flux through the circuit. This is a statement of :
- Faraday's laws
 - Lenz's law
 - Gauss's law
 - Ampere's law
19. The speed of propagation of an electromagnetic wave in free space of permeability μ_0 and permittivity ϵ_0 is :
- $1/\sqrt{\mu_0 \epsilon_0}$
 - $\sqrt{\mu_0 \epsilon_0}$
 - $\sqrt{\mu_0 / \epsilon_0}$
 - $\sqrt{\epsilon_0 / \mu_0}$

20. For an Ideal gas undergoing an adiabatic process, the pressure P , the Volume V and the ratio of the specific heats $\gamma = C_p/C_v$ are related as :
- (a) $PV^\gamma = \text{Constant}$ (b) $PV = \text{Constant}$
(c) $VP^\gamma = \text{Constant}$ (d) $(VP)^\gamma = \text{Constant}$
21. The mean length of the path travelled by a gas molecule as a free particle depends chiefly upon :
- (a) Temperature and Pressure
(b) Volume and number of particles
(c) Size of the molecules and their number density
(d) Temperature, Pressure and Volume
22. In the following, V_m stand for molar volume, a and b are van der Waal's constants, and R is the molar gas constant. The correct form of the van der Waal's equation of state is :
- (a) $\left(P - \frac{a}{V_m}\right)(V_m + b) = RT$ (b) $\left[P - \frac{a}{V_m}\right](V_m - b) = RT$
(c) $\left[P + \frac{a}{V_m}\right](V_m - b) = RT$ (d) $\left[P + \frac{a}{V_m}\right](V_m + b) = RT$
23. Critical point in a PVT diagram is the point where :
- (a) a solid goes directly to vapour on heating
(b) vapours and liquids become indistinguishable
(c) vapour, liquid and solid can co-exist together in thermal equilibrium
(d) the melting point decreases as pressure increases
24. If H is enthalpy, T is temperature, S is entropy, U is internal energy and F is Helmholtz free energy, which of the following expressions represents the Gibbs Free Energy, G ?
- (a) $H - TS$ (b) $U + TS$
(c) $U + PV$ (d) $H - U$
25. The correct Maxwell relation between the thermodynamic variables P , V , S , and T is :
- (a) $(\partial P/\partial T)_V = (\partial S/\partial V)_T$ (b) $(\partial T/\partial V)_S = -(\partial P/\partial S)_V$
(c) $(\partial T/\partial P)_S = (\partial V/\partial S)_P$ (d) All of these are correct

26. Read the following statements :
- Heat never flows spontaneously from a colder body to a hotter body
 - No engine can have 100% efficiency
 - The entropy of the universe never decreases
- Among the above statements, the following is a correct set of various statements of the second law of thermodynamics :
- i. and ii. only
 - i. and iii. only
 - ii. and iii. only
 - all i., ii. and iii.
27. A coin is flipped one hundred times and the outcomes recorded. How many macrostates and microstates are there respectively ?
- 1 and 2
 - 2 and 2
 - 1 and 100
 - 2 and 100
28. If the temperature of an ideal gas is doubled while holding the pressure constant, the rms speed of the molecule :
- is also doubled
 - becomes $\sqrt{2}$ times the original speed
 - becomes 4 times the original speed
 - becomes 8 times the original speed
29. Of the following properties of a wave, the one that is independent of the others is its :
- frequency
 - wavelength
 - speed
 - amplitude
30. Humans with excellent hearing can hear in the frequency range :
- 0 Hz – 20 KHz
 - 20 Hz – 20 KHz
 - 20 KHz – 20 MHz
 - 20 Hz – 20 MHz
31. Two thin lenses of magnification m_1 and m_2 (with $m_1 > m_2$) are used in combination. The magnification of the combined system is :
- $m_1 + m_2$
 - $m_1 - m_2$
 - $m_1 m_2$
 - m_1 / m_2
32. A curved mirror surface can have :
- both chromatic and spherical aberrations
 - chromatic aberration but not spherical aberrations
 - spherical aberration but not chromatic aberration
 - neither chromatic nor spherical aberrations

33. Two coherent, monochromatic light waves, each of intensity I , are incident on a point. The total intensity at that point is :
- 0
 - I
 - $4I$
 - The given information is insufficient
34. In a double slit experiment using light of wavelength 500 nm , the slit spacing is 1 mm and the screen is 2 m from the slit. Assuming small-angle approximation, the distance along the screen between adjacent bright fringes is :
- 1 cm
 - 0.50 cm
 - 0.10 cm
 - 0.01 cm
35. A LASER produces :
- a parallel, coherent and monochromatic beam of light
 - a parallel, non-coherent and monochromatic beam of light
 - a parallel, coherent but not necessarily monochromatic beam of light
 - an anti-parallel, coherent and monochromatic beam of light
36. According to Rayleigh's criterion, the minimum angle of resolution θ for a circular aperture of diameter D is :
- $\theta = \frac{1.22D}{\lambda}$
 - $\theta = \frac{D}{1.22\lambda}$
 - $\theta = \frac{\lambda}{1.22D}$
 - $\theta = \frac{1.22\lambda}{D}$
37. A light ray inside a glass prism is incident at Brewster's angle on the surface of the prism with air outside. Choose the correct statement from the following :
- There is no transmitted ray; the reflected ray is plane polarised
 - There is no reflected ray; the transmitted ray is plane polarised
 - Transmitted ray is partially polarized; the reflected ray is plane polarised
 - The reflected ray is partially polarized; the transmitted ray is plane polarised
38. An electron and a proton have the same de Broglie wavelength. Which of the following are also the same for the two particles ?
- momentum
 - momentum and kinetic energy
 - speed and kinetic energy
 - momentum and speed

39. A particle is trapped in a 1-D infinite square potential well with perfectly rigid walls. If E_0 is the energy of the particle in the ground state, then the difference in energy between the ground state and the first excited state is :
- (a) E_0 (b) $2E_0$
(c) $3E_0$ (d) $4E_0$
40. Identify the momentum operator from the following :
- (a) $i\hbar\nabla$ (b) $-i\hbar\nabla$
(c) $i\hbar\nabla^2$ (d) $-i\hbar\nabla^2$
41. Depending upon the orientation of the spin vector S , the energy of an atomic electron will be higher or lower than its energy without spin-orbit coupling, by the term (μ_B is the Bohr Magnetron)
- (a) $\mu_B B$ (b) $\mu_B B^2$
(c) μ_B/B^2 (d) $\mu_B B^3$
42. For the hydrogen atom in the $l = 3$ state, the magnitude of the orbital angular momentum L is :
- (a) $\sqrt{3}\hbar$ (b) $2\sqrt{3}\hbar$
(c) $3\sqrt{2}\hbar$ (d) $\sqrt{2}\hbar$
43. In an X-ray tube, as the energy of the electrons striking the metal target is increased, the wavelength of the characteristic X-rays :
- (a) increases
(b) decreases
(c) does not change
(d) increases for metals with odd number of valance electrons and decreases for metals with even number of valance electrons
44. Homomorphie molecules that lack permanent dipole moments can have :
- (a) rotational spectra (b) vibrational spectra
(c) electronic spectra (d) None of the above
45. In the harmonic oscillator approximation, the selection rules for transition between vibrational states is (v is the vibrational quantum number)
- (a) $\Delta v = 1, 2, 3$ (b) $\Delta v = 0, 1, 2, 3$
(c) $\Delta v = 1, 2, 3, 4$ (d) $\Delta v = \pm 1$
46. If the radius of a nucleus is doubled, the mass number A increases by a factor of :
- (a) 8 (b) 4
(c) 2 (d) $2^{2/3}$

47. A certain nuclide X decays into a daughter nuclide Y with the emission of an α particle and two β particles. The mass number A and the atomic number Z of the daughter compared to the parent :
- Z reduced by 4 units, A remains unchanged
 - A reduced by 4 units, Z remains unchanged
 - A reduced by 4 units, Z reduced by 2 units
 - A reduced by 4 units, Z increased by 2 units
48. Only one particle among the following has an integral spin. It is :
- Proton
 - Neutron
 - Electron
 - Photon
49. For a Tetragonal lattice system, the restrictions on the conventional Cell Axes and Angles are :
- $a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ$
 - $a = b = c, \alpha \neq \beta \neq \gamma$
 - $a = b \neq c, \alpha \neq \beta \neq \gamma$
 - $a = b \neq c, \alpha = \beta = \gamma = 90^\circ$
50. The reciprocal lattice to a simple cubic lattice is a :
- Simple cubic lattice
 - bcc lattice
 - fcc lattice
 - gcc lattice
51. The magnetic susceptibility of diamagnetic, paramagnetic and ferromagnetic substances respectively is
- positive but small, positive and large, negative
 - negative, positive but small, positive and large
 - negative, positive and large, positive but small
 - positive and large, negative, positive but small
52. According to Debye's law, the vibrational specific heat of solids at very low temperature varies as
- T
 - T^2
 - T^3
 - T^4
53. The forbidden energy gap in a solid is of the order of 1eV. The solid is most likely :
- An insulator at absolute zero
 - A semiconductor at room temperature
 - A conductor at low temperature
 - Both (a) and (b)

54. A phonon is :
- (a) a quantum of lattice vibrations
 - (b) a quantum of light
 - (c) a particle of half integral spin
 - (d) a lepton
55. When a current carrying conductor is placed across a magnetic field, a potential difference is generated in a direction :
- (a) parallel to the current and perpendicular to the magnetic field
 - (b) parallel to the magnetic field and perpendicular to the current
 - (c) parallel to both the magnetic field and the current
 - (d) perpendicular to both the magnetic field and the current
56. A piece of silver and another of germanium are cooled from room temperature to liquid nitrogen temperature. The resistance of :
- (a) each of them increases
 - (b) each of them decreases
 - (c) increases for silver and decreases for germanium
 - (d) decreases for silver and increases for germanium
57. Both the inputs of a logic gate are HIGH, and the output is LOW; the gate is :
- (a) an AND gate
 - (b) an OR gate
 - (c) a NAND gate
 - (d) None of these
58. A Zener diode is mainly used as :
- (a) an amplifier
 - (b) a voltage regulator
 - (c) an oscillator
 - (d) a filter
59. In a class C amplifier,
- (a) the output current is zero for more than one-half of an input sinusoidal signal cycle
 - (b) the output current is zero for less than one-half of an input sinusoidal signal cycle
 - (c) the output current is zero for the whole signal cycle
 - (d) the output current flows for the whole signal cycle
60. In the common collector transistor configuration, the current gain and the voltage gain are :
- (a) both high
 - (b) both low
 - (c) high and low respectively
 - (d) low and high respectively

PHYSICS

1. A boy sitting on the top most berth in the compartment of a train which is just going to stop on a railway station, drops an apple aiming at the open hand of his brother sitting vertically below at a distance of about two meters. The apple will fall :
 - (a) precisely on the hand of his brother
 - (b) slightly away from the hand of his brother in the direction of motion of the train
 - (c) slightly away from the hand of his brother in the direction opposite to the direction of motion of the train
 - (d) none of (a) to (c)
2. A body of mass m is rotated in a vertical circle of radius r . The minimum velocity of the body at the top most position for the string to remain just stretched is :
 - (a) $\sqrt{2gr}$
 - (b) \sqrt{gr}
 - (c) $\sqrt{3gr}$
 - (d) $\sqrt{4gr}$
3. Two particles of masses m_1 and m_2 ($m_1 > m_2$) attract each other with a force inversely proportional to the square of the distance between them. The particles are initially at rest and then released. Which of the following statements is correct ?
 - (a) Centre of mass (CM) moves towards m_1
 - (b) CM moves towards m_2
 - (c) CM remains at rest
 - (d) CM moves at right angles to the line joining m_1 and m_2
4. A metal ball hits a wall and does not rebound whereas a rubber ball of the same mass on hitting the wall with the same velocity rebounds back. It can be concluded that :
 - (a) metal ball suffers greater change in momentum
 - (b) rubber ball suffers greater change in momentum
 - (c) the initial momentum of metal ball is greater than initial momentum of rubber ball
 - (d) both suffer same change in momentum
5. In which case does the potential energy decrease ?
 - (a) on compressing a spring
 - (b) on stretching a spring
 - (c) on moving a body against the gravitational force
 - (d) on the rising of an air bubble in water

6. Two simple harmonic motions act on a particle. These harmonic motions are : $x = A \cos (\omega t + \delta)$ and $y = A \cos (\omega t + \alpha)$, where $\delta = \alpha + \pi/2$. The resulting motion is :
- (a) a circle and actual motion is counter clockwise
 - (b) a circle and actual motion is clockwise
 - (c) an ellipse and actual motion is counter clockwise
 - (d) an ellipse and actual motion is clockwise
7. According to the Hooke's law of elasticity, if stress is increased, the ratio of stress to strain :
- (a) increases
 - (b) decreases
 - (c) becomes zero
 - (d) remains constant
8. A piece of ice is floating in a jar containing water. When the ice melts, then the level of water :
- (a) rises
 - (b) falls
 - (c) remains unchanged
 - (d) rises or falls depending on the mass of ice
9. $\nabla \times (\phi \nabla \phi)$, where ϕ is a scalar function, is equal to :
- (a) zero
 - (b) $\nabla^2 \phi$
 - (c) $\phi \nabla^2$
 - (d) $\nabla^2 \phi^2$
10. Which of the following statements is *not* correct ?
- (a) Curl of a gradient is always zero
 - (b) Divergence of curl is always zero
 - (c) Divergence of gradient is always zero
 - (d) Vector product of two identical vectors is always zero

11. The total electric flux, leaving a spherical surface of radius one cm and surrounding an electric dipole is :
- q/ϵ_0
 - zero
 - $2q/\epsilon_0$
 - $8\pi r^2 q/\epsilon_0$
12. How does the electric field strength vary when we enter a uniformly charged spherical cloud ?
- decreases inversely as the square of the distance from the surface
 - decreases directly as the square of the distance from the surface
 - decreases directly as the square of the distance from the centre
 - decreases directly as the distance from the centre
13. A parallel plate capacitor with air as dielectric is charged to a potential V . It is then connected to an uncharged parallel plate capacitor filled with wax of dielectric constant K . The common potential of both capacitors is :
- V
 - KV
 - $(1 + K)V$
 - $V/(1 + K)$
14. Which of the following statements is *correct* when comparing electric field $\left(\vec{E}\right)$ and electric displacement $\left(\vec{D}\right)$?
- both \vec{E} and \vec{D} satisfy Coulomb's law
 - \vec{E} satisfies Coulomb's law and not \vec{D}
 - \vec{E} satisfies Gauss law and not \vec{D}
 - \vec{D} satisfies Gauss law and not \vec{E}
15. A uniform resistance wire of length l and diameter d has a resistance R . Another wire of same material has length $4l$ and diameter $2d$, the resistance will be :
- $2R$
 - R
 - $R/2$
 - $R/4$

16. An electron moves with some velocity along x -direction. If a magnetic field acts along y -direction, the force on the electron acts in :
- x -direction
 - y -direction
 - z -direction
 - arbitrary direction
17. A charged particle moving with velocity v is subjected to electric field E and magnetic field B . The particle will go undeflected if :
- E , B and v are mutually perpendicular and $v = E/B$
 - E is perpendicular to B
 - E is parallel to v and perpendicular to B
 - E and B both are parallel to v
18. Which of the following statements is correct ?
- both electric and magnetic dipole moments depend on the choice of the origin
 - electric dipole is always independent of the choice of the origin
 - electric dipole is independent of the choice of the origin only when total charge vanishes
 - magnetic dipole depends on the choice of the origin
19. What is the origin of Maxwell's equations ?
- classical mechanics
 - quantum mechanics
 - theory of relativity
 - experimental facts
20. For a plane monochromatic electromagnetic wave, which of the following equation demonstrates that electric and magnetic fields are perpendicular to each other :
- $\nabla \cdot \vec{E} = 0$
 - $\nabla \cdot \vec{E} = -\partial \vec{B} / \partial t$
 - $\nabla \cdot \vec{B} = 0$
 - none of (a) to (c)

21. Consider a macroscopic particle of mass m immersed in a liquid at temperature T . Let z -axis point in the direction of the gravitational field. The mean value of the x -component of the velocity (v_x) vanishes by symmetry. The fluctuation of $v_x(v_x^{-2})$ is equal to :
- (a) kT/m
 - (b) zero
 - (c) kT
 - (d) $kT/2$
22. Which of the following statement is *not* correct regarding the specific heat of a gas ?
- (a) classical theory shows that specific heat is always equal to $3R$ independent of the temperature
 - (b) Einstein's theory predicts that at high temperatures specific heat is equal to $3R$
 - (c) Einstein's theory predicts that at low temperatures specific heat is equal to $3R$
 - (d) experimental data shows that specific heat at low temperatures is proportional to T^2
23. van der Waals equation can be obtained by considering that :
- (a) all the molecules move independent of each other
 - (b) each molecule interacts with an average potential generated by other molecules
 - (c) only pairwise interaction among the molecules
 - (d) gas is very dilute
24. In a mechanical refrigerator, the low temperature coils of the evaporator are at -23°C and the compressed gas in the condenser has a temperature of 77°C . The coefficient of performance is :
- (a) 70%
 - (b) 20%
 - (c) 0.23
 - (d) 2.5
25. We consider a thermodynamic system. If ΔU represents the increase in its internal energy and W the work done by the system, which of the following statements is *true* ?
- (a) $\Delta U = -W$ is an adiabatic process
 - (b) $\Delta U = W$ is an adiabatic process
 - (c) $\Delta U = -W$ is an isothermal process
 - (d) $\Delta U = W$ is an isothermal process

26. Absolute temperature below 1°K are measured using :
- (a) ordinary thermometer
 - (b) first law of thermodynamics and known temperature dependence of a macroscopic quantity
 - (c) second law of thermodynamics and known temperature dependence of a macroscopic quantity
 - (d) Curie's law
27. A critical point is :
- (a) where liquid-gas equilibrium line ends
 - (b) volume changes between liquid and gas approaches zero
 - (c) beyond which no further phase transformation is possible
 - (d) all of (a) to (c)
28. A system of dipoles has maximum statistical weight when :
- (a) all the dipoles are aligned parallel to the external magnetic field
 - (b) all the dipoles are aligned anti-parallel to the external magnetic field
 - (c) half of the dipoles are parallel and half anti-parallel to the external magnetic field
 - (d) none of (a) to (c)
29. The reason that Maxwellian distribution of speeds has Gaussian shape is :
- (a) the molecules considered are non-interacting
 - (b) translational motion of the centre of mass is only considered
 - (c) Boltzmann probability is considered in the derivation
 - (d) all of (a) to (c)
30. A Fermi system is in the ground state if :
- (a) all the states below the Fermi level are occupied at zero temperature
 - (b) all the states below the Fermi level are occupied at room temperature
 - (c) one of the states above the Fermi level is occupied
 - (d) all the states above the Fermi level are occupied

31. In a sinusoidal wave, the time required for a particular point to move from maximum displacement to zero displacement is 0.17 sec. The frequency of the wave is :
- (a) 2.94 Hz
 - (b) 1.47 Hz
 - (c) 0.36 Hz
 - (d) 0.73 Hz
32. A wave represented by equation $y = a \cos(kx - \omega t)$ is superposed with another wave to form a stationary wave such that point $x = 0$ is a node. The equation for the other wave is :
- (a) $a \sin(kx + \omega t)$
 - (b) $-a \cos(kx + \omega t)$
 - (c) $-a \cos(kx - \omega t)$
 - (d) $-a \sin(kx - \omega t)$
33. When we hear a sound, we can identify its source from :
- (a) amplitude of sound
 - (b) intensity of sound
 - (c) wavelength of sound
 - (d) overtones present in the sound
34. Inner walls of big halls should be good sound :
- (a) amplifier
 - (b) reflector
 - (c) absorber
 - (d) transmitter
35. An achromatic convergent lens of focal length +20 cm is made of two lenses (in contact) of materials having dispersive powers in the ratio of 1 : 2 and having focal lengths f_1 and f_2 , which of the following is true ?
- (a) $f_1 = 10$ cm, $f_2 = -20$ cm
 - (b) $f_1 = 20$ cm, $f_2 = 10$ cm
 - (c) $f_1 = -10$ cm, $f_2 = -20$ cm
 - (d) $f_1 = 20$ cm, $f_2 = -10$ cm

36. In Ramsden's eyepiece, the field lens and eye lens have focal lengths f_1 and f_2 respectively and separated by distance d then :
- (a) $f_1 = (2/3)f_2; d = (2/3)f_1$
 - (b) $f_1 = f_2; d = f_1 + f_2$
 - (c) $f_1 = f_2; d = (2/3)f_1$
 - (d) $f_1 = 3f_2; f_1 + f_2$
37. In Young's double slit experiment, we get 60 fringes in the field of view of monochromatic light of wavelength 4000 \AA . If we use monochromatic light of wavelength 6000 \AA , then the number of fringes obtained in the same field of view is :
- (a) 90
 - (b) 40
 - (c) 60
 - (d) 1.5
38. The condition for observing Fraunhofer diffraction from a single slit is that the light wavefront incident on the slit should be :
- (a) spherical
 - (b) cylindrical
 - (c) elliptical
 - (d) plane
39. To observe diffraction, the size of an obstacle :
- (a) should be of the same order as wavelength
 - (b) should be much larger than the wavelength
 - (c) have no relation to wavelength
 - (d) should be exactly half of the wavelength
40. Electromagnetic waves are transverse in nature is evident from :
- (a) interference
 - (b) diffraction
 - (c) polarization
 - (d) reflection

41. The apparent length of a meter stick measured by an observer at rest when the stick is moving along its length with a velocity equal to c :
- zero
 - infinite
 - one meter
 - none of (a) to (c)
42. The kinetic energy of a particle moving with relativistic speed v is given by (m_0 is the rest mass) :
- $\frac{1}{2}m_0v^2$
 - $\frac{1}{2} \frac{m_0v^2}{\sqrt{(1-v^2/c^2)}}$
 - $\frac{m_0c^2}{\sqrt{(1-v^2/c^2)}}$
 - $\left(\frac{m_0}{\sqrt{(1-v^2/c^2)}} - m_0 \right) c^2$
43. An electron and proton have the same de-Broglie wavelength. Then the kinetic energy of the electron is :
- zero
 - greater than the kinetic energy of the proton
 - less than the kinetic energy of the proton
 - equal to the kinetic energy of the proton
44. When yellow light is incident on a surface no electrons are emitted, while green light can emit. If red light is incident on the surface :
- no electrons will be emitted
 - photons are emitted
 - electrons of higher energy are emitted
 - electrons of lower energy are emitted
45. For particle in a one-dimensional box, the probability of finding the particle, which is in the first excited state $n = 2$, is :
- same throughout the box
 - zero throughout the box
 - minimum in the middle
 - maximum in the middle

46. The speed of an electron in the orbit of hydrogen atom in the ground state is :
- (a) c
 - (b) $c/10$
 - (c) $c/2$
 - (d) $c/137$
47. Discrete X-ray spectrum is obtained from :
- (a) transitions of the electrons from inner most orbits
 - (b) transitions of the electrons from outer most orbits
 - (c) molecular vibrations
 - (d) nuclear rotations
48. Molecular rotation is possible for :
- (a) non-polar molecules
 - (b) polar molecule
 - (c) H_2 molecule
 - (d) all molecules
49. The binding energy per nucleon is maximum for :
- (a) He^4
 - (b) Ba^{141}
 - (c) Fe^{56}
 - (d) U^{235}
50. The range of nuclear force is about :
- (a) 2×10^{-10} m
 - (b) 1.5×10^{-20} m
 - (c) 7.2×10^{-4} m
 - (d) 1.4×10^{-15} m

51. Which of the following is *not* the property of a crystalline substance ?
- (a) isotropic electrical conductivity
 - (b) long range order
 - (c) flat surface
 - (d) sharp melting point
52. The three axes of a crystal lattice are mutually perpendicular and two of the lattice parameters are equal. The crystal system is :
- (a) cubic
 - (b) tetragonal
 - (c) orthorhombic
 - (d) hexagonal
53. The properties of phonons are determined from inelastic scattering of :
- (a) gamma rays
 - (b) α -particles
 - (c) X-rays
 - (d) electrons
54. The paramagnetic contribution to magnetization originates from :
- (a) only spin of the electron
 - (b) only orbital motion of the electron
 - (c) both spin and orbital motion of the electron
 - (d) change in orbital moment induced by an applied magnetic field
55. Energy bands in solids is a consequence of :
- (a) Ohm's law
 - (b) Bohr's theory
 - (c) Heisenberg's uncertainty principle
 - (d) Pauli's exclusion principle

56. At zero kelvin, a piece of Germanium :
- (a) becomes a semiconductor
 - (b) becomes good conductor
 - (c) becomes bad conductor
 - (d) has maximum conductivity
57. When N-P-N transistor is used in an amplifier, then :
- (a) holes move from emitter to base
 - (b) electrons move from base to collector
 - (c) holes move from base to emitter
 - (d) electrons move from collector to base
58. The cause of potential barrier in a P-N junction is :
- (a) depletion of positive charges near the junction
 - (b) concentration of positive charges near the junction
 - (c) depletion of negative charges near the junction
 - (d) concentration of positive and negative charges near the junction
59. A transistor is preferable to a triode valve because it :
- (a) does not require a heater
 - (b) can withstand large changes in temperature
 - (c) has high input impedance
 - (d) can handle large power
60. In N-P-N transistor circuit, the collector current is 10 mA. If 90% of the electrons emitted reach the collector :
- (a) the emitter current will be 9 mA
 - (b) the emitter current will be 11 mA
 - (c) the emitter current will be 1 mA
 - (d) the emitter current will be 0.1 mA

PHYSICS

1. The force which is always directed away or towards a fixed centre and magnitude of which is a function of distance only from the fixed centre is known as :
 - (A) Coriolis force
 - (B) Central force
 - (C) Centrifugal force
 - (D) Centripetal force
2. If the kinetic energy of a body becomes four times of its initial value, then new momentum will be :
 - (A) three times its initial value
 - (B) four times its initial value
 - (C) two times its initial value
 - (D) unchanged
3. The polar coordinates of a particle at any instant t are $r = 8e^{2t}$, $\theta = 4t$. Then radial component of acceleration is :
 - (A) $16 e^{2t}$
 - (B) $12 e^{2t}$
 - (C) 12
 - (D) 0
4. The potential energy of a harmonic oscillator in its resting position is 12 joules and average kinetic energy is 5 joules. Then the total energy at any instant is :
 - (A) 17 joules
 - (B) 22 joules
 - (C) 5 joules
 - (D) 12 joules

5. Moment of inertia of a uniform circular disc about a diameter is I . Its moment of inertia about an axis perpendicular to its plane and passing through a point on its rim will be :
- (A) $4 I$
(B) $6 I$
(C) $3 I$
(D) $5 I$
6. Two simple harmonic waves having same frequency and each of amplitude A , superimpose. The resultant energy when two waves have phase difference of $\frac{\pi}{2}$ is given by (k being a constant) :
- (A) $3 kA^2$
(B) $4 kA^2$
(C) 0
(D) $2 kA^2$
7. Consider a beam of electrons moving parallel to two separate cylinders C_1 and C_2 kept at potential ϕ_1 and ϕ_2 respectively. The beam converges if :
- (A) $\phi_1 < \phi_2$
(B) $\phi_2 > \phi_1$
(C) $\phi_1 = \phi_2$
(D) All the above conditions from (A) to (C) are satisfied
8. A particle of mass m and charge e moves with speed V in the plane perpendicular to a uniform magnetic field B . Its period of revolution will :
- (A) be independent of B
(B) be independent of speed
(C) be inversely proportional to m
(D) depend on the radius of orbit

9. In streamline flow of liquid, the total energy of liquid is constant at :
- (A) inner points
 (B) outer points
 (C) the centre
 (D) all points
10. The Bernoulli's theorem is applicable if the flow of the liquid is :
- (A) irrotational and liquid should be compressible
 (B) rotational and liquid should be compressible
 (C) irrotational and liquid should be incompressible
 (D) rotational and liquid should be incompressible
11. If $\vec{A} = 3\hat{i}x$, $\vec{B} = 5\hat{j}y$, then $\nabla(\vec{A} \cdot \vec{B})$ is equal to :
- (A) $5\hat{i}y + 3\hat{j}x$
 (B) $\frac{3}{2}yx^2\hat{i} + \frac{5}{2}xy^2\hat{j}$
 (C) 2
 (D) 0
12. Let \vec{r} be the position vector of any point on the surface of a cube of side L, then surface integral $\iint_S \vec{r} \cdot d\vec{S}$ is :
- (A) $3L^3$
 (B) $3L^2$
 (C) $2L^2$
 (D) 0

13. Polarization of a dielectrical material occurs due to :
- (A) electrons
 (B) bound charges
 (C) free charges
 (D) none of the above
14. The electric potential at a point due to an electric dipole is perpendicular to the dipole axis, if the angle between dipole axis and the line joining the point with centre of dipole is :
- (A) $\tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$
 (B) $\tan^{-1}(1)$
 (C) $\tan^{-1}(\sqrt{2})$
 (D) $\tan^{-1}(\sqrt{3})$
15. The electric field intensity \vec{E} due to an infinite uniformly charge plane sheet at a point of distance r from the sheet is related as :
- (A) $E \propto r$
 (B) $E \propto \frac{1}{r}$
 (C) $E \propto r^2$
 (D) E is independent of r
16. Consider a boundary between two dielectric and dielectric field makes an angle θ_1 and θ_2 with the media of permittivity ϵ_1 and ϵ_2 respectively, then we have :
- (A) $\frac{\tan \theta_1}{\tan \theta_2} = \frac{\epsilon_1}{\epsilon_2}$
 (B) $\frac{\tan \theta_1}{\tan \theta_2} = \frac{\epsilon_2}{\epsilon_1}$
 (C) $\frac{\tan \theta_1 + \tan \theta_2}{\tan \theta_2} = \frac{\epsilon_1}{\epsilon_2}$
 (D) $\frac{\tan \theta_1 + \tan \theta_2}{\tan \theta_1} = \frac{\epsilon_2}{\epsilon_1}$

17. If u_E and u_M are respectively, the electric and magnetic energy derivatives of a plane electromagnetic wave propagation in free space, then :

(A) $u_E = 2u_M$

(B) $u_E = u_M$

(C) $u_E = \frac{1}{2}u_M$

(D) $u_E = \frac{3}{2}u_M$

18. When a pure inductance L and pure capacitance C are connected in parallel and a.c. voltage V is applied across the system, then at resonance the current from the source is :

(A) $\frac{V}{\omega L}$

(B) $-V\omega C$

(C) 0

(D) Very large

19. The magnetic induction \vec{B} and magnetic vector potential \vec{A} are related by :

(A) $\vec{A} = \vec{\nabla} \times \vec{B}$

(B) $\vec{\nabla} \times (\vec{A} \times \vec{B}) = 0$

(C) $\vec{B} = -\vec{\nabla} \times \vec{A}$

(D) $\vec{B} = \vec{\nabla} \times \vec{A}$

20. If magnetic monopole existed, then which of the following Maxwell's equation will be modified :

(A) $\vec{\nabla} \cdot \vec{D} = \rho$

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

(C) $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

(D) $\vec{\nabla} \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$

21. In kinetic theory of gases, it is assumed that collision between the molecules is :

(A) perfectly elastic

(B) perfectly inelastic

(C) partly elastic

(D) partly inelastic

22. If the degree of freedom of a gas is 'n', then the ratio of specific heat at constant pressure C_p to specific heat at constant volume C_v is :

(A) $1 + \frac{1}{n}$

(B) $1 + \frac{2}{n}$

(C) $1 + \frac{1}{2n}$

(D) $\frac{2n}{1 + 2n}$

23. Which of the following Maxwell's relation leads to Clausius-Clapeyron equation ?

(A) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial V}\right)_V$

(B) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$

(C) $\left(\frac{\partial T}{\partial P}\right)_S = \left(\frac{\partial V}{\partial S}\right)_P$

(D) $\left(\frac{\partial V}{\partial T}\right)_P = \left(\frac{\partial S}{\partial P}\right)_T$

24. The permissible microstates corresponding to a given macrostate satisfy the constraint/constraints :

(A) $\delta N \neq 0, \delta E \neq 0$

(B) $\delta N = 0, \delta E \neq 0$

(C) $\delta N = 0, \delta E = 0$

(D) $\delta N \neq 0, \delta E = 0$

25. For a perfect gas $\left(\frac{\partial U}{\partial V}\right)_T = 0$, while for a gas obeying van der Waals' equation

$\left(\frac{\partial U}{\partial V}\right)_T$ is equal to :

(A) aV^2

(B) $(V - b)$

(C) $\frac{1}{V - b}$

(D) $\frac{a}{V^2}$

26. For cooling to take place in a Joule-Thomson experiment, the initial temperature of gas should be :
- (A) equal to the inversion temperature
 (B) less than the inversion temperature
 (C) more than inversion temperature
 (D) more than or equal to the inversion temperature
27. If a system A is in thermal equilibrium separately with B and C, then B and C are also in thermal equilibrium with each other. This is the statement of :
- (A) Zeroth law of thermodynamics
 (B) First law of thermodynamics
 (C) Second law of thermodynamics
 (D) Third law of thermodynamics
28. The quantum statistics reduces to classical statistics under the following condition (ρ is the number density of particles and λ is the thermal de-Broglie wavelengths) :
- (A) $\rho\lambda^3 = 1$
 (B) $\rho\lambda^3 \gg 1$
 (C) $\rho\lambda^3 \ll 1$
 (D) $\rho = 0$
29. In statistical physics, the absolute temperature T of a system is related to the total number of accessible state Ω by :
- (A) $kT = \frac{\partial\Omega}{\partial E}$
 (B) $\frac{1}{kT} = \frac{\partial\Omega}{\partial E}$
 (C) $kT = \frac{\partial \log \Omega}{\partial E}$
 (D) $\frac{1}{kT} = \frac{\partial \log \Omega}{\partial E}$

30. In a gas the relative magnitude of the most probable speed (V_p), the average speed (\bar{V}) and root mean speed (V_{rms}) of the molecule are :
- (A) $V_{rms} > \bar{V} > V_p$
 - (B) $\bar{V} > V_{rms} > V_p$
 - (C) $V_p > \bar{V} > V_{rms}$
 - (D) $V_p > V_{rms} > \bar{V}$
31. The reverberation time is the time which energy density of sound wave falls to 10^{-5} of its :
- (A) maximum steady value
 - (B) half maximum steady value
 - (C) minimum steady value
 - (D) mean value
32. If the intensity of sound is doubled, then intensity level difference increases by :
- (A) 50 dB
 - (B) 30 dB
 - (C) 10 dB
 - (D) 3 dB
33. An ultrasonic sound pulse is sent vertically down the ocean waters and the echo is received 3 seconds later. The depth of the ocean at that place is approximately :
- (A) 4.40 km
 - (B) 3.30 km
 - (C) 2.20 km
 - (D) 1.10 km

34. If the equation of motion of a longitudinal wave is $y = 0.15 \sin (4\pi t - 2\pi x)m$, and let the displacement of a particle due to this wave is 0.15 m, its kinetic energy is :
- (A) 4.8 J
 - (B) 2.4 J
 - (C) 1.14 J
 - (D) zero
35. The minimum number of lines in a grating which will just resolve the spectral lines of wavelength 5890 Å and 5896 Å in second order is :
- (A) 491
 - (B) 981
 - (C) 2940
 - (D) 2943
36. The resolving power of a telescope is the highest for :
- (A) red light
 - (B) yellow light
 - (C) green light
 - (D) blue light
37. The power of Huygen's eye-piece is :
- (A) zero
 - (B) positive
 - (C) negative
 - (D) none of the above

38. In Michelson's interferometer sodium light is used for circular fringes. The distances of separation of two mirrors for two consecutive positions of least contrast are equal to d_1 and d_2 . If λ_1 and λ_2 are wavelengths of two lines of sodium light, then their difference ($\lambda_1 - \lambda_2$) is equal to :

(A) $\frac{\lambda_1 \lambda_2}{2(d_2 - d_1)}$

(B) $\frac{\lambda_1 \lambda_2}{2(d_2 + d_1)}$

(C) $\frac{3\lambda_1 \lambda_2}{2(d_2 - d_1)}$

(D) $\lambda_1 \lambda_2 (d_2 + d_1)$

39. Chromatic aberration can be eliminated by using two convex lenses of focal lengths, f_1 and f_2 respectively. Which are separated by a distance equal to :

(A) $d = (f_1 - f_2)$

(B) $d = (f_1 + f_2)$

(C) $d = \frac{(f_1 + f_2)}{2}$

(D) $\frac{1}{d} = \frac{1}{f_1} + \frac{1}{f_2}$

40. For a system of atoms and photons in equilibrium at a temperature T , the ratio of transition rate of stimulated to spontaneous emission is given by :

(A) $e^{h\nu/kT}$

(B) $e^{-h\nu/kT}$

(C) $\frac{1}{e^{h\nu/kT} - 1}$

(D) $1 - e^{h\nu/kT}$

41. A light beam moves in positive x -direction with speed of light c . Another light beam moves in the negative x -direction with same speed. To an observer sitting on the first beam, the second beam appears to move with speed :

- (A) $2c$
- (B) c
- (C) 0
- (D) $\frac{c}{2}$

42. Let rest mass of a body be m_0 and if it is moving with the velocity of $0.8c$, then its relativistic kinetic energy is :

- (A) $\frac{1}{2}m_0(0.8c)^2$
- (B) $m_0c^2 - \frac{1}{2}m_0(.8c)^2$
- (C) $\frac{3}{2}m_0c^2$
- (D) $\frac{2}{3}m_0c^2$

43. The uncertainty in the location of a particle is equal to de-Broglie wavelength, then the uncertainty in its velocity is :

- (A) $\frac{3}{2}V$
- (B) $2V$
- (C) V
- (D) $\frac{V}{2}$

44. For an electron orbit with orbital quantum number $l = 2$, the possible values of components of total angular momentum along specified direction (z -axis) are :

(A) $\pm \frac{1}{2} \left(\frac{h}{2\pi} \right), \pm \frac{3}{2} \left(\frac{h}{2\pi} \right)$
(B) $\pm \frac{3}{2} \left(\frac{h}{2\pi} \right), \pm \frac{5}{2} \left(\frac{h}{2\pi} \right)$
(C) $\pm \frac{1}{2} \left(\frac{h}{2\pi} \right), \pm \frac{5}{2} \left(\frac{h}{2\pi} \right)$
(D) $\pm \frac{1}{2} \left(\frac{h}{2\pi} \right), \pm \frac{3}{2} \left(\frac{h}{2\pi} \right), \pm \frac{5}{2} \left(\frac{h}{2\pi} \right)$

45. The lowest energy for a particle in a box of length L is (m is mass of the particle) :

(A) $\frac{\hbar^2 \pi^2 x^2}{2mL^2}$
(B) $\frac{\hbar^2 \pi^2}{2mL^2}$
(C) $\sqrt{\frac{2}{L}} \sin \frac{n\pi x}{L}$
(D) $\frac{n\hbar}{2\pi}$

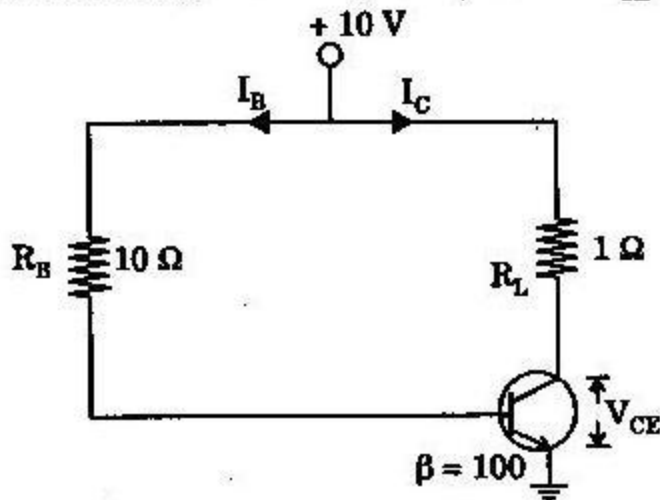
46. If the frequency of k_{α} X-ray emitted from the element with atomic number 31 is f , then frequency of k_{α} X-ray emitted from the element with atomic number 51 is :

(A) $\frac{25}{9} f$
(B) $\frac{5}{3} f$
(C) $\frac{51}{31} f$
(D) $\frac{9}{25} f$

47. The vibrational-rotational molecular spectra arises as energy involved in such a transition is of the order of :
- (A) 0.001 eV
 - (B) 0.01 eV
 - (C) 0.1 eV
 - (D) 10 eV
48. A Raman frequency shift of 3000 cm^{-1} is observed for a substance. The substance will show infrared absorption at :
- (A) 0.3 μm
 - (B) 3 μm
 - (C) 30 μm
 - (D) 300 \AA
49. The source of energy of the sun is due to :
- (A) fusion of heavy nuclei
 - (B) fusion of light nuclei
 - (C) fusion of very heavy nuclei
 - (D) fusion and fission process
50. The tunnel effect makes possible :
- (A) α -decay
 - (B) positive β -decay
 - (C) negative β -decay
 - (D) gamma decay
51. The basic structure of NaCl is :
- (A) simple cubic
 - (B) fcc
 - (C) bcc
 - (D) hexagonal closed packed

52. According to Kronig-Penny model the energy spectrum of electron :
- (A) is continuous
 - (B) consists of alternate regions of allowed and forbidden energy of equal width
 - (C) consists of alternate regions of allowed and forbidden energy such that width of energy bands increases with the increase of energy
 - (D) consists of alternate regions of allowed and forbidden energy such that width of allowed energy bands with the increase of energy
53. According to Debye's model for the lattice specific heat at low temperature, its value is proportional to :
- (A) T^3
 - (B) T^2
 - (C) T
 - (D) $e^{-hv/kT}$
54. The first Brillouin zone of the lattice in the k -space is between :
- (A) 0 to $\frac{\pi}{a}$
 - (B) $-\frac{\pi}{a}$ to $+\frac{\pi}{a}$
 - (C) $-\frac{\pi}{a}$ to $-\frac{2\pi}{a}$
 - (D) $+\frac{\pi}{a}$ to $+\frac{2\pi}{a}$
55. When electrons leave the N-material to fill holes in the P-material, the process is called :
- (A) doping
 - (B) mixing
 - (C) depletion
 - (D) diffusion

56. For the C.E. circuit of figure below, the value of V_{CE} is (take $\beta = 100$) :



- (A) 5 V
 (B) -5 V
 (C) 0
 (D) 20 V
57. Leakage current of a junction diode :
 (A) is in the range of mA to μ A
 (B) is due to majority carriers
 (C) depends on the method of its fabrication
 (D) decreases with temperature
58. The most desirable feature of transformer coupled amplifiers is its :
 (A) ability to provide impedance matching between stages
 (B) higher voltage gain
 (C) wide frequency range
 (D) ability to eliminate hum from the output
59. In a JFET drain current is maximum when V_{GS} is :
 (A) zero
 (B) negative
 (C) positive
 (D) equal to V_p
60. The h -parameters are called hybrid because they :
 (A) are obtained from different characteristics
 (B) are mixed with other parameters
 (C) apply to circuits contained in a black box
 (D) are defined by using both open and short circuit terminations

PHYSICS

1. If the Cartesian coordinates of a point are $(1, 0, 0)$, then the spherical polar coordinates of the same point are :
 - (A) $(0, 90^\circ, 0)$
 - (B) $(0, 90^\circ, 180^\circ)$
 - (C) $(1, 90^\circ, 0)$
 - (D) $(0, 180^\circ, 90^\circ)$
2. Coriolis force is experienced :
 - (A) in inertial frame of reference only
 - (B) in non-inertial frame of reference only
 - (C) both in inertial and non-inertial frames
 - (D) neither in inertial nor in non-inertial frames
3. A mass m is moving with a constant velocity along a line parallel to the x -axis from the origin. Its angular momentum w.r.t. the origin :
 - (A) is zero
 - (B) goes on increasing
 - (C) goes on decreasing
 - (D) is constant
4. The moment of inertia of a solid sphere and a spherical shell of equal masses about their diameters are equal. The ratio of their radii is :
 - (A) $3 : 5$
 - (B) $5 : 3$
 - (C) $\sqrt{3} : \sqrt{5}$
 - (D) $\sqrt{5} : \sqrt{3}$

5. A body executes S.H.M. with an amplitude A . At what displacement from the mean position is the potential energy of the body one-fourth of its total energy ?
- (A) $A/4$
 - (B) $A/2$
 - (C) $3A/4$
 - (D) $\frac{A}{\sqrt{2}}$
6. The amplitude of the transient state :
- (A) increases exponentially with time
 - (B) decreases exponentially with time
 - (C) falls suddenly to zero
 - (D) becomes infinite after some time
7. An electric charge in a uniform motion produces :
- (A) an electric field only
 - (B) a magnetic field only
 - (C) both electric and magnetic field
 - (D) no such field at all
8. The limitation of a cyclotron is that it can't be used to accelerate neutral particles like neutrons because they :
- (A) experience force in electric fields only
 - (B) experience force in magnetic fields only
 - (C) experience force both in electric and magnetic fields
 - (D) do not experience force in electric and magnetic fields

9. A wire is stretched by a force such that its length becomes double. Then Young's modulus of rigidity Y of the wire will :
- (A) have no change
 - (B) become double of its original value
 - (C) become half of its original value
 - (D) become four times of its original value
10. When terminal velocity is reached, the acceleration of the body moving through viscous medium is :
- (A) Positive
 - (B) Negative
 - (C) Zero
 - (D) Equal to acceleration due to gravity
11. A vector field \vec{A} is said to be irrotational if :
- (A) $\vec{\nabla} \times \vec{A} = 0$
 - (B) $\vec{\nabla} \cdot \vec{A} = 0$
 - (C) $\vec{\nabla} \times \vec{A} = 1$
 - (D) $\vec{\nabla} \cdot \vec{A} = 1$
12. If

$$\vec{A} = \frac{x}{r}\hat{i} + \frac{y}{r}\hat{j} + \frac{z}{r}\hat{k},$$

where \vec{r} is the position vector, then $\nabla \cdot \vec{A}$ is given by :

- (A) $\frac{2}{r^2}$
- (B) $\frac{2}{r}$
- (C) Zero
- (D) 3

13. The electric field intensities due to a dipole on its axial line and equatorial line are represented by E_{axial} and E_{equ} respectively, then relation between them is given by :
- (A) $E_{\text{axial}} = E_{\text{equ}}$.
 - (B) $E_{\text{axial}} = 4E_{\text{equ}}$.
 - (C) $E_{\text{axial}} = 2E_{\text{equ}}$.
 - (D) $E_{\text{axial}} = \frac{1}{2}E_{\text{equ}}$.
14. A surface of a charged conductor is always under a electrostatic pressure acting :
- (A) randomly
 - (B) inward
 - (C) outward
 - (D) none of the above
15. A parallel plate capacitor with oil between the plates (dielectric constant of oil $k = 2$) has a capacitance C . If the oil is removed, then capacitance of capacitor becomes :
- (A) $\frac{C}{2}$
 - (B) $\frac{C}{\sqrt{2}}$
 - (C) $2C$
 - (D) $\sqrt{2}C$
16. An LCR series circuit is connected to a source of alternating current. At resonance, the applied voltage and the current flowing through the circuit will have a phase difference of :
- (A) π
 - (B) $\pi/2$
 - (C) $\pi/4$
 - (D) 0

17. A magnetic material is non-uniformly magnetised. If the magnetisation at any point in a material is given by $xz^2\hat{i} + xy\hat{j}$, then equivalent current density \vec{J} is :

(A) $2xz\hat{j} + y\hat{k}$

(B) $2xz\hat{j} + x\hat{k}$

(C) $xz^2\hat{i} + y\hat{k}$

(D) $xz^2\hat{i} + x\hat{k}$

18. If k is dielectric constant and χ_e is electric susceptibility, then relation between them is given by :

(A) $k = \frac{1 - \chi_e}{1 + \chi_e}$

(B) $k = \frac{1 + \chi_e}{1 - \chi_e}$

(C) $k = 1 + \chi_e$

(D) $k = 1 - \chi_e$

19. If ϵ_0 and μ_0 represent the permittivity and permeability of vacuum, ϵ and μ represent the permittivity and permeability of medium, then refractive index of the medium is given by :

(A) $\sqrt{\frac{\epsilon_0 \mu_0}{\epsilon \mu}}$

(B) $\sqrt{\frac{\epsilon \mu}{\epsilon_0 \mu_0}}$

(C) $\sqrt{\frac{\epsilon}{\mu_0 \epsilon_0}}$

(D) $\sqrt{\frac{\mu_0 \epsilon_0}{\epsilon}}$

20. In an electromagnetic wave the rate of flow of energy per unit area along the direction of propagation of the wave is given by :
- (A) $(\vec{E} \times \vec{B})/\mu$
 (B) $(\vec{E} \times \vec{B})/\epsilon$
 (C) $(\vec{E} \times \vec{B})/\mu \epsilon$
 (D) $(\vec{E} \times \vec{B})$
21. For an ideal gas in an adiabatic process at a constant pressure P, the rate of change of internal energy U with temperature T is :
- (A) a negative constant
 (B) directly proportional to T
 (C) a positive constant
 (D) zero
22. Mean free path of gas molecules is inversely proportional to :
- (A) Temperature
 (B) Volume
 (C) Pressure
 (D) None of the above
23. For a perfect gas $\left(\frac{\partial U}{\partial V}\right)_T = 0$, while for a gas obeying van der Waals' equation $\left(\frac{\partial U}{\partial V}\right)_T$ is equal to :
- (A) aV^2
 (B) $(V - b)$
 (C) $\frac{1}{V - b}$
 (D) $a\sqrt{V^2}$

24. At temperature above the temperature of inversion, the gases show :
- (A) heating effect
 - (B) cooling effect
 - (C) neither cooling nor heating effect
 - (D) both cooling and heating effects
25. Which of the following is *not* one of Maxwell's four thermodynamic relations ?
- (A) $\left(\frac{\partial T}{\partial P}\right)_N = -\left(\frac{\partial P}{\partial S}\right)_V$
 - (B) $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$
 - (C) $\left(\frac{\partial T}{\partial V}\right)_S = -\left(\frac{\partial P}{\partial S}\right)_V$
 - (D) $\left(\frac{\partial U}{\partial V}\right)_S = -\left(\frac{\partial U}{\partial S}\right)_V$
26. If the initial and final temperatures are T_1 and T_2 absolute, then efficiency of Carnot engine is given by :
- (A) $\eta = 1 - \frac{T_1}{T_2}$
 - (B) $\eta = 1 - \frac{T_2}{T_1}$
 - (C) $\eta = \frac{T_1}{T_2}$
 - (D) $\eta = \frac{T_2}{T_1}$

27. All accessible microstates corresponding to possible macrostates are equally probable. This is the most fundamental postulate of Statistical Mechanics and is called :
- (A) Postulate of additive law of probability
 - (B) Postulate of multiplicative law of probability
 - (C) Postulate of equal a priori probability
 - (D) Postulate of independent law of probability
28. According to Boltzmann's canonical distribution law, the low energy cells will contain :
- (A) less particles than high energy cells
 - (B) more particles than high energy cells
 - (C) infinite particles than high energy cells
 - (D) equal number of particles in high energy cells
29. In Maxwell-Boltzmann distribution, the most probable speed is defined as when :
- (A) Probability distribution is zero
 - (B) Probability distribution is one
 - (C) Probability distribution is maximum
 - (D) Probability distribution is minimum
30. Bose-Einstein statistics is based on quantum statistics given by indistinguishable particles of :
- (A) Integral spin
 - (B) Half spin
 - (C) Pauli's exclusion principle
 - (D) Electron spins

31. Which of the following does *not* affect the reverberation time of a room ?
- (A) Area of the walls
 - (B) Volume
 - (C) Frequency
 - (D) Absorption coefficient
32. Sound waves having which frequency are audible by human being ?
- (A) 5 cycles/sec
 - (B) 27,000 cycles/sec
 - (C) 5,000 cycles/sec
 - (D) 50,000 cycles/sec
33. When two sound waves of same frequency and amplitude are 180 degrees out of phase, the result is :
- (A) beats
 - (B) increased loudness
 - (C) resonance
 - (D) silence
34. One of the practical applications of reflection of sound is :
- (A) speaking tube
 - (B) ear trumpet
 - (C) the sound board
 - (D) all the examples above are practical application of reflection of sound

35. According to Fermat's principle of all the paths connecting two points, the path actually followed by light is :
- (A) maximum only
 - (B) minimum only
 - (C) either maximum or minimum
 - (D) none of the above
36. For an achromatic combination of two lenses in contact the lenses should have :
- (A) equal dispersive powers
 - (B) same focal length
 - (C) unequal dispersive powers and should be either both convex or both concave
 - (D) unequal dispersive powers and one should be convex and the other concave
37. In an interference pattern minima has zero intensity when the disturbances superimposed have :
- (A) unequal amplitudes
 - (B) equal amplitudes
 - (C) unequal phases
 - (D) none of the above

38. In case of a grating the ratio of the wavelength of a line in the spectrum to the least difference in the wavelength of the next line that can just be seen as separate is known as :
- (A) dispersive power
 - (B) magnifying power
 - (C) resolving power
 - (D) luminosity power
39. In elliptically polarised light :
- (A) the amplitude of the vibrations changes in direction as well as in magnitude
 - (B) the amplitude of the vibrations changes in magnitude only
 - (C) the magnitude of the vibrations changes in direction only
 - (D) none of the above statements is correct
40. A laser is a coherent source because it contains :
- (A) many frequencies
 - (B) uncoordinated waves of a particular frequency
 - (C) coordinated waves of many wavelengths
 - (D) coordinated waves of a particular frequency

41. At what fraction of the velocity of light must a body move in order that its rest mass increases three times ?
- (A) $\frac{2\sqrt{2}}{3}$
- (B) $\frac{\sqrt{2}}{3}$
- (C) $\frac{\sqrt{3}}{2}$
- (D) $\sqrt{\frac{2}{3}}$
42. Lengths of objects in motion :
- (A) appear increased in the direction of motion
- (B) appear decreased in the direction of motion
- (C) are the same as for stationary objects
- (D) appear decreased perpendicular to the direction of motion
43. A photon and electron have got same de-Broglie wavelength. If E_1 and E_2 are total energies of photon and electron respectively, then :
- (A) $E_2 = E_1$
- (B) $E_2 < E_1$
- (C) $E_2 > E_1$
- (D) $E_2 = E_1 = 0$
44. The physical significance of principal quantum number n in hydrogen atom governs :
- (A) total energy of electron
- (B) magnitude of angular momentum of electron
- (C) direction of angular momentum of electron
- (D) total angular momentum of electron

45. The Lande's 'g' factor for s electron is equal to :
- (A) 1
(B) 2
(C) 1/2
(D) 3/2
46. K_{β} -line in an X-ray spectra will arise when an electron from :
- (A) the K-shell goes to L-shell
(B) the M-shell goes to K-shell
(C) the M-shell goes to L-shell
(D) the N-shell goes to K-shell
47. If the angular frequencies of the incident and the scattered photons in Raman scattering are ω and ω' respectively, then :
- (A) $\omega' > \omega$ for the anti-stokes lines
(B) $\omega' > \omega$ for the stokes lines
(C) $\omega' > \omega$ for the stokes as well as anti-stokes lines
(D) $\omega' < \omega$ for the stokes as well as anti-stokes lines
48. A rigid diatomic molecule is free to rotate in a fixed plane. The rotational energy eigen values are given by :
- (A) $\frac{ml}{2h^2}$
(B) $\frac{2ml}{h^2}$
(C) $\frac{\hbar^2 l}{2m}$
(D) $\frac{\hbar m^2}{2l}$

49. The nucleus ${}_{48}\text{Cd}^{115}$, after two successive β -decays will give :
- (A) ${}_{48}\text{Pa}^{113}$
 (B) ${}_{48}\text{Cd}^{114}$
 (C) ${}_{50}\text{Sn}^{113}$
 (D) ${}_{50}\text{Sn}^{115}$
50. According to liquid drop model, when a nucleus is bombarded by neutrons, the compound nucleus attains the given shapes in the sequence :
- (A) ellipsoidal, spherical, dumb-bell
 (B) spherical, ellipsoidal, dumb-bell
 (C) spherical, dumb-bell, ellipsoidal
 (D) dumb-bell, ellipsoidal, spherical
51. The number of atoms per unit bcc cell is :
- (A) 4
 (B) 3
 (C) 2
 (D) 1
52. If \vec{K} represents wave vector space and \vec{G} represents reciprocal lattice, then Bragg's diffraction condition is given by :
- (A) $\vec{K} \cdot \vec{G} + G^2 = 0$
 (B) $\vec{K} \cdot \vec{G} - G^2 = 0$
 (C) $\vec{K} \cdot \vec{G} + 2G^2 = 0$
 (D) $2\vec{K} \cdot \vec{G} + G^2 = 0$

53. According to Langevin's classical theory of diamagnetism, the susceptibility of diamagnetism substance is :

- (A) proportional to number of electrons Z
- (B) inversely proportional to number of electrons Z
- (C) independent of number of electrons Z
- (D) None of the above statements

54. The Fermi energy in a metal is given by (m^* is effective mass of electron) :

(A)
$$E_f = \frac{\hbar^2}{m^*} \left(\frac{3N}{8\pi V} \right)^{\frac{2}{3}}$$

(B)
$$E_f = \frac{\hbar^2}{2m^*} \left(\frac{3N}{8\pi V} \right)^{\frac{1}{3}}$$

(C)
$$E_f = \frac{\hbar^2}{2m^*} \left(\frac{3N}{8\pi V} \right)^{\frac{2}{3}}$$

(D)
$$E_f = \frac{\hbar^2}{m^*} \left(\frac{3N}{8\pi V} \right)^{\frac{1}{3}}$$

55. In an N-type semiconductor, there are :

- (A) no majority carriers
- (B) immobile negative ions
- (C) immobile positive ions
- (D) holes as majority carriers

56. When a P-N junction of a diode is forward-biased, diffusion current causes :

- (A) covalent bonding
- (B) forward bonding
- (C) reverse-biasing
- (D) establishment of barrier potential

57. The value of I_E in the circuit shown in the below given Fig. is (taking $\beta = 100$) :

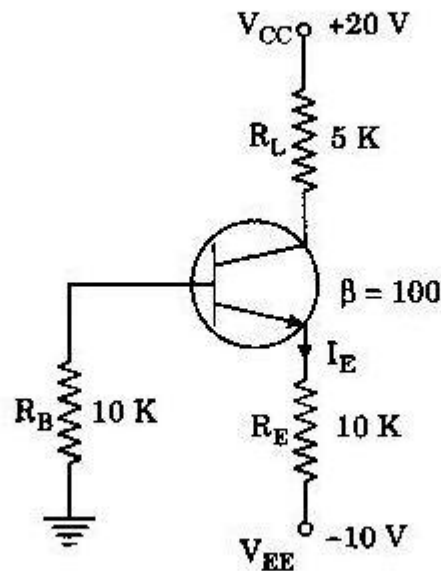


Fig.

- (A) 9.9 mA
 (B) 0.99 mA
 (C) 9.9 A
 (D) 0.099 mA
58. For small values of drain-to-source voltage, JFET behaves like a :
 (A) resistor
 (B) constant-current source
 (C) constant-voltage source
 (D) negative resistance
59. The most desirable feature of transformer coupling is its :
 (A) higher voltage gain
 (B) wide frequency range
 (C) ability to provide impedance matching between stages
 (D) ability to eliminate hum from the output
60. The smallest of the four h -parameters of a transistor is :
 (A) h_i
 (B) h_o
 (C) h_r
 (D) h_f