Sr. No. ....

ENTRANCE TEST-2023

SCHOOL OF PHYSICAL AND MATHEMATICAL SCIENCE

PHYSICS

Question Booklet Series **A**

Total Questions : 60

Time Allowed : 70 Minutes

Roll No. : | | | | | | |

Instructions for Candidates :

1. Write your Entrance Test 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.

1. Two bodies of masses 3×10^{-24} kg and 6×10^{-25} kg are moving with velocities 0.002c m/s and 0.01c m/s respectively towards each other under a mutually attractive force. The velocity of their centre of mass is (where 'c' is the velocity of light) :
(A) 0.015c m/s
(B) 0.003c m/s
(C) 0 m/s
(D) c m/s

2. A spaceship has a length of 100 m in its rest frame and appears to be 80.0 m to an observer in an earth frame. The relative velocity of the reference frames is :
(A) 0.600c
(B) 0.500c
(C) 0.300c
(D) 0.900c

3. Two relativistic particles with opposite velocities collide head-on and come to rest by sticking with each other. Which of the following quantity is not conserved ?
(A) Total linear momentum
(B) Total energy
(C) Total rest mass
(D) None of the above quantities is conserved

4. Observes in relative motion with speed '*v*' are connected by a Lorentz transformation :
(A) $x' = \gamma(x - vt),\ y' = y,\ z' = z,\ t' = t$
(B) $x' = \gamma(x - vt),\ y' = y,\ z' = z,\ t' = \gamma t$
(C) $x' = \gamma(x - vt),\ y' = y,\ z' = z,\ t' = \gamma\left(t - \frac{vx}{c}\right)$
(D) $x' = \gamma(x - vt),\ y' = y,\ z' = z,\ t' = \gamma\left(t - \frac{vx}{c^2}\right)$

5. If we assume that the earth has exact spherical symmetry, then, g at a height h above the surface can be approximately expressed as :
(A) $\left(\frac{GMe}{R_e^2}\right)\left(1 + \frac{2h}{R_e}\right)$
(B) $\left(\frac{GMe}{R_e}\right)\left(1 - \frac{2h}{R_e}\right)$
(C) $\left(\frac{GMe}{R_e^2}\right)\left(1 - \frac{h}{2R_e}\right)$
(D) $\left(\frac{GMe}{R_e^2}\right)\left(1 - \frac{2h}{R_e}\right)$

6. A uniform disk of mass M and radius R rolls, without slipping, down a fixed plane inclined at an angle of 45° to the horizontal. The linear acceleration of the disk (in ms^{-2}) is closest to :
(A) 4.6
(B) 4.2
(C) 9.8
(D) 4.9

7. The time period of revolution of an artificial satellite moving around Jupiter in a circular orbit at a distance 'R' from its centre is T. If the same satellite is taken to an orbit of radius 9R around the same planet, the time period would be :
(A) 9T
(B) 27T
(C) T/9
(D) 3T

8. The ratio of the moment of inertia of a spherical shell about a tangent axis to the moment of inertia about its centroidal axis is :
(A) 5/3
(B) 5/2
(C) 7/2
(D) 7/3

9. Which of the following identity is NOT correct ?

(A) $\nabla(fg) = f\,\nabla g + g\nabla f$

(B) $\nabla\cdot(f A) = f\,(\nabla\cdot A) + A\cdot(\nabla f)$

(C) $\nabla\times(f A) = f\,(\nabla\times A) + A\times(\nabla f)$

(D) $\nabla\times(f A) = f\,(\nabla\times A) - A\times(\nabla f)$

10. Which of the following is a possible electrostatic field ?

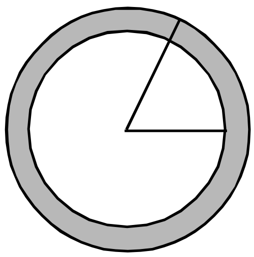
(A) $E = A[xy\hat{i} + 2yz\hat{j} + 3xz\hat{k}]$

(B) $E = A[y^2\hat{i} + (2xy + z^2)\hat{j} + 2yz\hat{k}]$

(C) $E = A[x^2\hat{i} + (2z^2 + xy)\hat{j} + yz\hat{k}]$

(D) $E = A[z^2\hat{i} + (2y + 3xz)\hat{j} + yz\hat{k}]$

11. A thick spherical shell carries charge density $\rho = \frac{k}{r^2}$ $(a \le r \le b)$, the electric field in the region $(a < r < b)$ is :



(A) $\left(\frac{k}{\epsilon_0}\right)\left(\frac{r-a}{r^2}\right)\hat{r}$

(B) $\left(\frac{k}{\epsilon_0}\right)\left(\frac{a-r}{r^2}\right)\hat{r}$

(C) $\left(\frac{k}{\epsilon_0}\right)\left(\frac{b-a}{r^2}\right)\hat{r}$

(D) 0

12. The amplitude of a lightly damped harmonic oscillator decreases at the rate of 5% per minute. The loss of energy of the oscillator per minute will be closest to :

(A) 5%

(B) 10%

(C) 15%

(D) 20%

13. A parallel-plate capacitor is filled with an insulating material of dielectric constant K. Then, which of the following statement is NOT true ?

(A) The dielectric material will reduce the electric field inside the capacitor by a factor of 1/K

(B) The dielectric material will increase the electric potential inside the capacitor by a factor of 1/K

(C) The capacitance of the parallel-plate capacitor is increased by a factor of K

(D) The electric field is confined to the spaces between the plates

14. Ampere's law cannot be used for :

(A) Calculating magnetic field due to infinite planes carrying steady currents

(B) Calculating magnetic field due to infinite solenoids carrying steady currents

(C) Calculating magnetic field due to infinite straight wires carrying steady as well as non-steady currents

(D) Calculating magnetic field due to toroid carrying steady currents

15. Choose the correct statement :

(A) The magnetic susceptibility of paramagnetic materials is temperature independent

(B) The magnetic susceptibility of diamagnetic materials is nearly independent of temperature

(C) The magnetic susceptibility of ferromagnetic materials increases with temperature

(D) The magnetic susceptibility of paramagnetic materials increases with temperature

16. Which of the following does not represent the basic equation of Magnetostatics ?
   (A) $\nabla \times A = B$
   (B) $\nabla \times H = J$
   (C) $\nabla \cdot B = 0$
   (D) $\nabla \cdot B = |J|$
17. A short cylindrical bar magnet and an identical unmagnetized iron piece are both dropped simultaneously from the tops of two identical, vertical aluminium pipes (of slightly larger diameter and 2 meters long), then :
   (A) It takes a fraction of a second for the unmagnetized iron to emerge at the bottom
   (B) It takes a fraction of a second for the bar magnet to emerge at the bottom
   (C) It takes several seconds for the unmagnetized iron to emerge at the bottom
   (D) The bar magnet just hangs near the middle of the aluminium pipe
18. The self-inductance per unit length of a long solenoid, of radius R, carrying n turns per unit length is given by :
   (A) $L = \frac{\mu_0 R}{\pi} n$
   (B) $L = \mu_0 \pi R^2 n$
   (C) $L = \mu_0 \pi R^2 n^2$
   (D) $L = \frac{\mu_0 \pi R^2}{n}$
19. The electric field associated with an electromagnetic wave is given by

$$E = (3\hat{k} - \hat{j}) \sin (8x + 4y + z - \alpha t)$$

   The value of α is (c is the speed of light) :
   (A) c
   (B) 3c
   (C) 6c
   (D) 9c
20. Which of the following statement is correct ?
   (A) Galilean transformation equations can be applied to Maxwell's equations in free space
   (B) Maxwell's equations show that electromagnetic waves travel at different speeds in different inertial frames
   (C) Maxwell's equations in free space are invariant under Lorentz transformation
   (D) Maxwell's equations were able to unify the theories of electromagnetism and thermodynamics
21. The relation between C_p and C_v is given by :
   (A) $C_p - C_v = -T\left(\frac{\partial S}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P^2$
   (B) $C_p - C_v = -T\left(\frac{\partial S}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P$
   (C) $C_p - C_v = -T\left(\frac{\partial p}{\partial V}\right)_T \left(\frac{\partial S}{\partial T}\right)_P^2$
   (D) $C_p - C_v = -T\left(\frac{\partial p}{\partial V}\right)_T \left(\frac{\partial V}{\partial T}\right)_P^2$
22. If 1 mole of an ideal gas is allowed to expand isothermally to 8 times its initial volume, the entropy change in terms of the gas constant R is closest to :
   (A) 2
   (B) 1
   (C) 3
   (D) 4

23. The volume expansion coefficient α at constant pressure is given by :

(A) $\alpha = \frac{1}{v}\left(\frac{\partial V}{\partial T}\right)_p$

(B) $\alpha = V\left(\frac{\partial V}{\partial T}\right)_p$

(C) $\alpha = \frac{1}{v}\left(\frac{\partial V}{\partial S}\right)_p$

(D) $\alpha = \frac{1}{v}\left(\frac{\partial S}{\partial T}\right)_p$

24. Which of the following statement is incorrect according to the 3rd law of thermodynamics ?

(A) All expansion coefficients tend to be zero as the temperature approaches absolute zero

(B) As the temperature approaches absolute zero, the susceptibility of a paramagnetic salt increases rapidly

(C) The entropy changes in all reversible isothermal processes tend to zero as the temperature approaches absolute zero

(D) It is not possible to reduce any assembly to the absolute zero of temperature by any process however idealized in a finite number of operations

25. Which of the following set of differential equations characterises a given hydrostatic system, where dU, dH, dF and dG are changes in internal energy, enthalpy, Helmholtz energy and Gibbs energy respectively ?

(A) $dU = TdS - pdV$
$dH = TdS + Vdp$
$dF = SdT - pdV$
$dG = -SdT + Vdp$

(B) $dU = TdS - pdV$
$dH = TdS + Vdp$
$dF = -SdT - pdV$
$dG = SdT + Vdp$

(C) $dU = TdS - pdV$
$dH = TdS + Vdp$
$dF = -SdT + pdV$
$dG = -SdT + Vdp$

(D) $dU = TdS - pdV$
$dH = TdS + Vdp$
$dF = -SdT - pdV$
$dG = -SdT + Vdp$

26. The mean translational energy per degree of freedom for the molecules of a gas obeying Maxwell's distribution is :

(A) $k_B T$

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

(C) $\frac{3}{2} k_B T$

(D) $2 k_B T$

27. The mean free path of an atomic gas obeying Maxwell's distribution of velocities is :

(A) Directly proportional to temperature

(B) Inversely proportional to temperature

(C) Directly proportional to the size of the atoms

(D) Directly proportional to the density of the gas

28. The coefficients of viscosity and diffusion for a gas are 2.31×10^{-6} Nsm^{-2} and 1.78×10^{-6} $m^2 s^{-1}$, respectively. Given the average molecular speed is 330 ms^{-1}, the density and mean free path respectively are :

(A) 1.61 kg m^{-3} and 8.32×10^{-8} m

(B) 1.72 kg m^{-3} and 6.32×10^{-8} m

(C) 1.29 kg m^{-3} and 1.61×10^{-8} m

(D) 1.56 kg m^{-3} and 8.32×10^{-8} m

29. At absolute zero, the Fermi-Dirac distribution function n(ε) is given by :

(Where kB is the Boltzmann constant, T is the temperature and εf is the Fermi energy)

(A) $n(\varepsilon) = \dfrac{1}{e^{\frac{\varepsilon - \varepsilon f}{k_B T}} + 1}$

(B) $n(\varepsilon) = \dfrac{1}{e^{\frac{\varepsilon - \varepsilon f}{k_B T}} - 1}$

(C) $n(\varepsilon) = \dfrac{1}{e^{\frac{\varepsilon f - \varepsilon}{k_B T}} - 1}$

(D) $n(\varepsilon) = \dfrac{1}{e^{\frac{\varepsilon f - \varepsilon}{k_B}} + 1}$

30. The total number of microstates for a system of 5 indistinguishable particles distributed over four non-degenerate levels of energies 0, ε, 2ε, 3ε is :

(A) 120

(B) 625

(C) 1024

(D) 24

31. Which of the following statement is incorrect ?

(A) According to Planck's law exchange of energy between matter and radiation can only take place in bundles of a certain size

(B) According to Planck's law the quantum of energy is directly proportional to its frequency

(C) Radiation pressure is independent of the volume of an enclosure and varies as the fourth power of temperature is direct result of Wien's law

(D) Planck's law explains all the observed results in the entire spectral range for blackbody radiation

32. A blackbody at temperature T emits radiation at a peak wavelength λ. If the temperature of the blackbody becomes 6T, the new peak wavelength is :

(A) $\dfrac{\lambda}{6}$

(B) $\dfrac{\lambda}{36}$

(C) $\dfrac{\lambda}{12}$

(D) $\dfrac{\lambda}{18}$

33. Two harmonic waves represented by :

$Y_1 = 5 \cos (12t - 13x)$m and

$Y_2 = 5 \cos (8t - 11x)$m

are superposed to form a wave group. The group velocity of the wave group is :

(A) 1 m/s

(B) 2 m/s

(C) 3 m/s

(D) 4 m/s

34. One-dimensional wave equation is represented by :

(A) $\frac{\partial^2\psi}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2\psi}{\partial^2 t}$

(B) $\frac{\partial^2\psi}{\partial x^2} = \frac{1}{v}\frac{\partial^2\psi}{\partial^2 t}$

(C) $\frac{\partial\psi}{\partial x} = \frac{1}{v^2}\frac{\partial^2\psi}{\partial^2 t}$

(D) $\left(\frac{\partial\psi}{\partial x}\right)^2 = \frac{1}{v^2}\frac{\partial^2\psi}{\partial t^2}$

35. In the Newton's Rings experiment if the incident light consists of two wavelengths 4000 Å and 4002 Å then the distance (from the point of contact) at which the rings will disappear is given by (assume that the radius of curvature of the curved surface is 400 cm) :

(A) 8 cm

(B) 4 cm

(C) 2 cm

(D) 1 cm

36. In the Michelson interferometer arrangement, if one of the mirrors is moved by a distance of 0.08 mm, 250 fringes cross the field of view. The wavelength of monochromatic light used is :

(A) 5400 Å

(B) 6400 Å

(C) 6800 Å

(D) 5800 Å

37. If the intensity distribution produced by a single slit is represented as I_{single}, then the distribution produced by a double slit in Fraunhofer diffraction is given by :

(A) $I_{double} = I_{single} \cos^2\beta$

(B) $I_{double} = 2I_{single} \cos^2\beta$

(C) $I_{double} = 4I_{single} \cos^2\beta$

(D) $I_{double} = I_{single} \cos\beta$

where $\beta = \frac{\pi}{\lambda} d \sin\theta$, and 'd' is the distance between the two slits.

38. For $\lambda = 10 \times 10^{-5}$ cm, the most intense focal point of a zone-plate with raddi, $r_n = 0.2\sqrt{n}$ cm will be at a distance of :

(A) 200 cm

(B) 400 cm

(C) 600 cm

(D) 800 cm

39. The displacement y of a travelling wave in the x-direction is given by :

$$y = 10^{-5} \sin\left(450t - 3x + \frac{\pi}{5}\right) m$$

where x is in meters and t is in seconds, then the speed of the wave motion is :

(A) 450 m/s

(B) 100 m/s

(C) 150 m/s

(D) 300 m/s

40. The ratio of potential energy to the kinetic energy of a body executing SHM when the displacement is equal to one-fourth of the amplitude is :

(A) 1 : 4

(B) 1 : 16

(C) 1 : 32

(D) 1 : 15

41. The photoelectric threshold wavelength for Nickel (work function of Ni = 5 eV) is :

(A) 248 nm

(B) 210 nm

(C) 560 nm

(D) 380 nm

42. The de Broglie wavelength of a tennis ball of mass 140 g after it is slammed across a wall with a speed of 15 m/s is approximately :

(A) 2.7×10^{-33} m

(B) 2.7×10^{-34} m

(C) 3.4×10^{-33} m

(D) 3.1×10^{-34} m

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

(A) $i\hbar \frac{d}{dx}$

(B) $-i\hbar \frac{d}{dx}$

(C) $i\hbar \frac{d}{dt}$

(D) $i\hbar^2 \frac{d}{dx}$

44. The ground state radial probability density for the Hydrogen atom is proportional to (where a_0 is the Bohr Radius) :

(A) $r e^{\frac{-r}{a_0}}$

(B) $r^2 e^{\frac{-r}{a_0}}$

(C) $r^2 e^{\frac{-2r}{a_0}}$

(D) $r^2 e^{\frac{2r}{a_0}}$

45. Which of the following statement is incorrect ?

(A) In j–j coupling the spin and orbital angular momentum of each particle add to give a total angular momentum j for that particle, and then J equals the sum of the individual j vectors

(B) In L–S coupling the spins of all the particles and the orbital angular momenta of all the particles add to yield total S and total L, which then add to yield J

(C) In presence of a magnetic field the splitting of the energy levels in the atom gives rise to a splitting of the spectral lines emitted by the atom

(D) Atomic states with different n values but the same j values have slightly different energies because of the interaction of the spin of the electron with its orbital motion

46. Which of the following statement is incorrect ?

(A) There are three generations of leptons, each consisting of a charged lepton and its related neutrino

(B) The photon is the most familiar lepton and is the only one that is stable

(C) Muon is the second-generation lepton with a lifetime of 2.197×10^{-6} s

(D) The tau neutrino is stable and has a weak isospin of 1/2

47. Which of the following set of α-decay chains is possible ?

(A) 4n, (4n – 1), (4n – 2), (4n – 3)

(B) 4n, (4n + 1), (4n + 2), (4n + 3)

(C) 4n, (4n + 2), (4n + 4), (4n + 8)

(D) 4n, (4n – 2), (4n – 4), (4n – 8)

48. The colour charge of a quark has which of the following possible values ?

(A) Red, blue and green

(B) Yellow, blue and green

(C) Yellow, blue and white

(D) Yellow, white and green

49. The reciprocal lattice corresponding to a direct face-centred cubic lattice is a :

(A) Face-centred lattice

(B) Simple cubic lattice

(C) Body-centred cubic lattice

(D) Hexagonal lattice

50. Choose the incorrect statement :

(A) The heat capacity of most insulators at low temperatures is proportional to the cube of the temperature

(B) The heat capacity of most conductors at low temperatures is proportional to the first power of the temperature

(C) According to the Debye model, the heat capacity of a solid at high temperatures is equal to 3 Nk_B, where N is the number of unit cells in the solid

(D) According to the Einstein's model, the heat capacity of a solid at high temperatures is equal to $3Nk_B$, where N is the number of unit cells in the solid

51. In winter, a metal block is cold to touch than a wooden block, although both are at the same temperature. The most appropriate reason is that :

(A) In metals, the heat energy is carried away by phonons only

(B) In metals, the thermal conductivity is only determined by free electrons

(C) In metals, the thermal conductivity is determined by both phonons and free electrons, thereby making the coefficient of thermal conductivity 'K' large

(D) It is because meals have small values of 'K'

52. Identify the incorrect statement about the tunnel diodes :

(A) Tunnel diodes are capable of very fast operation by using quantum mechanical effects

(B) The positive differential resistance in their operation, allows them to be used as oscillators

(C) In forward-biased tunnel diodes, there is a region in the V-I characteristics where an increase in forward voltage is accompanied by a decrease in forward current

(D) Tunnel diodes are p-n-junctions, where conduction band electron states on the n-side are more or less aligned with valence band hole states on the p-side

53. Which of the following semiconductor parameter can be determined from the knowledge of the Hall Coefficient ?

(A) Fermi level and band gap

(B) Temperature coefficient of resistivity

(C) Mobility and concentration of charge carriers

(D) All the above parameters can be determined

54. In a p-n junction diode, the current due to the majority electron carriers in the n region is given by (where I_o is the current with no bias and V is the forward bias applied) :

(A) $I_o e^{-\frac{eV}{kT}}$

(B) $I_o e^{\frac{eV}{kT}}$

(C) $I_o e^{-\frac{eV^2}{kT}}$

(D) $I_o e^{\frac{eV^2}{kT}}$

55. The ratio of conduction electron concentration (per cm^3) at room temperature of a typical metal (copper) to that of a typical intrinsic semiconductor (germanium) is approximately equal to :

(A) 10^{22}

(B) 10^{18}

(C) 10^{10}

(D) 10^{14}

56. The application of a magnetic field on a semiconductor :

(A) Decreases the resistivity of a semiconductor and produces a decrease in the magnitude of the Hall coefficient

(B) Increase the resistivity of a semiconductor and produces an increase in the magnitude of the Hall coefficient

(C) Decreases the resistivity of a semiconductor and produces an increase in the magnitude of the Hall coefficient

(D) Increases the resistivity of a semiconductor and produces a decrease in the magnitude of the Hall coefficient

57. For using a transistor as an amplifier, the correct option regarding the resistances of base-emitter (RBE) and base-collector (RBC) junctions is :

(A) Very high R_{BE} and very low R_{BC}

(B) Very low R_{BE} and very high R_{BC}

(C) Both R_{BE} and R_{BC} are very low

(D) Both R_{BE} and R_{BC} are very high

58. Which of the following statements is NOT true ?

(A) For an ideal MOSFET biased in saturation, the magnitude of the small signal current gain for a common drain amplifier is infinite

(B) MOSFET is a voltage-controlled device

(C) When the drain voltage in an n-MOSFET is negative, it operates in inactive region

(D) MOSFET can be used as a voltage-controlled inductor

59. Which of the following statements is correct ?

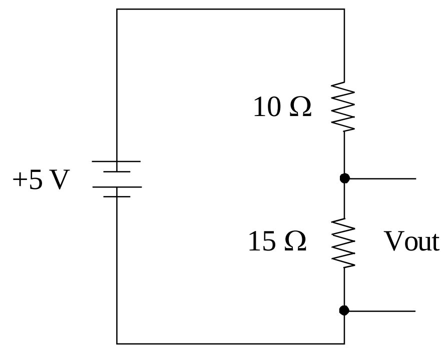
(A) RC coupling is used for power amplification

(B) The frequency response of transformer coupling is excellent

(C) The voltage gain is practically expressed in dB

(D) The final stage of a multistage amplifier uses RC coupling

60. The output voltage of the circuit below is :



(A) 3V

(B) 6V

(C) 9V

(D) 12V

ROUGH WORK

ROUGH WORK

Sr. No. 354

ENTRANCE TEST-2022

SCHOOL OF PHYSICAL & MATHEMATICAL SCIENCES

PHYSICS

Total Questions : 60

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Question Booklet Series B

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SEAL

1. A given amount of heat cannot be completely converted into work. However, it is possible to convert a given amount of work completely into heat. This statement results from :

(A) Zeroth law of thermodynamics

(B) First law of thermodynamics

(C) Second law of thermodynamics

(D) Third law of thermodynamics

2. For a thermodynamic system, work done in a given process depends upon :

(A) The path

(B) State of the system

(C) External pressure

(D) Nature of the system

3. In a refrigerator, the heat exhausted to the outer atmosphere is :

(A) Less than that absorbed from the contents of the refrigerator

(B) Same as that absorbed from the contents

(C) More than that absorbed from the contents

(D) Any of the above depending upon the working substance

4. The internal energy of a perfect monoatomic gas at 27°C is :

(A) Only kinetic

(B) Only potential

(C) Partly kinetic and potential

(D) Only vibrational

5. Which of the following relations is correct where γ is specific heat ratio, f is the number of degrees of freedom ?

(A) $\gamma = 1 + f$

(B) $\gamma = 1 - f$

(C) $\gamma = 1 + \frac{f}{2}$

(D) $\gamma = 1 + \frac{2}{f}$

6. The thermodynamical potential, enthalpy is $H = U + pV$, where U is the internal energy, p the pressure and V is the volume. Then :

(A) $T = -\left(\frac{\partial H}{\partial S}\right)_V$ and $V = \left(\frac{\partial H}{\partial p}\right)_S$

(B) $T = \left(\frac{\partial H}{\partial S}\right)_V$ and $V = \left(\frac{\partial H}{\partial p}\right)_S$

(C) $T = -\left(\frac{\partial H}{\partial p}\right)_S$ and $V = \left(\frac{\partial H}{\partial S}\right)_V$

(D) $T = \left(\frac{\partial H}{\partial p}\right)_S$ and $V = \left(\frac{\partial H}{\partial S}\right)_V$

7. A fluid at high pressure is throttled through a narrow porous opening in a region of lower pressure without any transfer of heat. In such a process :

(A) The entropy does not change

(B) The Gibbs free energy remains constant

(C) The entropy is decreased

(D) The enthalpy of the fluid is constant

8. Under equilibrium conditions, the thermodynamic variable associated with the black body radiation at temperature T which reduces to zero is :

(A) Entropy

(B) Helmholtz free energy

(C) Gibbs free energy

(D) Pressure

9. The spectrum of radiation emitted by a black body at a temperature 1000K peaks in the region :

(A) Visible range of frequencies

(B) Infrared range of frequencies

(C) Ultraviolet range of frequencies

(D) Microwave range of frequencies

10. The average value of velocity v in Maxwellian distribution of speeds is :

(A) Zero

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

(C) $\frac{kT}{m}$

(D) $\sqrt{\frac{kT}{m}}$

11. The mean translational kinetic energy per molecule of an ideal gas is :

(A) kT

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

(C) $\frac{3}{2}kT$

(D) $\frac{2}{3}kT$

12. According to the Fermi-Dirac statistics the number of particles in a phase cell can be :

(A) Any number

(B) Only two

(C) Only three

(D) Only one

13. Two tuning forks A and B of nearly equal frequencies are employed in an optical experiment to produce Lissajous figures. On slightly loading fork A, it is observed that the cycle of change of figure slows down from 10 to 20 seconds. If the frequency of fork B is 256 Hz, the frequency of fork A after loading is :

(A) 256.05 Hz

(B) 200.05 Hz

(C) 156.05 Hz

(D) 100.05 Hz

14. A plane wave traverses a medium, the displacement of particles is given by $\psi(x, t) = 0.01 \sin(4\pi t - 0.02\pi x)$, ($\psi$ and x are measured in meters and seconds), then the amplitude and wavelength of the wave are respectively :

(A) 0.01 m and 100 m

(B) 0.01 s and 100 m

(C) 0.01 m and 100 s

(D) 1 m and 100 m

15. An object of mass 2 kg hangs from a spring of negligible mass. The spring is extended by 2.5 cm when the object is attached. The top end of the spring is oscillating up and down in SHM with an amplitude of 2 mm. If $g = 10 ms^{-2}$, then the angular frequency of the oscillations is :

(A) 200 rad s^{-1}

(B) 20 rad s^{-1}

(C) 10 rad s^{-1}

(D) 100 rad s^{-1}

16. The fringe width in terms of wavelength (λ), distance between the slits and screen (D) and distance of separation of slits (d) is :

(A) $\frac{\lambda d}{D}$

(B) $\frac{\lambda^2 D}{d}$

(C) $\frac{\lambda D^2}{d}$

(D) $\frac{\lambda D}{d}$

17. In a double slit interference experiment, one of the slits is covered by thin mica sheet whose refractive index is 1.58. The distance d = 0.1 cm and D = 50 cm. Due to introduction of mica, the central fringe gets shifted by 0.2 cm. The thickness of mica sheet is :

(A) 6.7×10^{-4} cm

(B) 2.2×10^{-4} cm

(C) 1.1×10^{-4} cm

(D) 0.1×10^{-4} cm

18. Monochromatic light of wavelength 600 nm is used in a Young's double slit experiment. One of the slits is covered by a transparent sheet of thickness 1.8×10^{-5} m made up of material of refractive index 1.6. The number of fringes that shift due to introduction of sheet is :

(A) 6

(B) 12

(C) 18

(D) 20

19. Consider two waves passing through the same string. Principle of superposition for displacement says that the net displacement of a particle on the string is the sum of the displacements produced by the two waves individually. Suppose we state the similar principle for the net velocity and the net kinetic energy of the particle. Such a principle will be valid for :

(A) Both the velocity and the kinetic energy

(B) The velocity but not for the kinetic energy

(C) The kinetic energy but not the velocity

(D) Neither the velocity nor the kinetic energy

20. The positions of the principal maxima are given by grating equation :

(A) $d^2 \sin\theta = m\lambda$, m = 0,1,2,....

(B) $\lambda \sin\theta = md$, m = 0,1,2,....

(C) $d \sin^2\theta = m^2\lambda$, m = 0,1,2,....

(D) $d \sin\theta = m\lambda$, m = 0,1,2,....

21. The de-Brogile wavelength of a particle with charge q and mass m is accelerated through a potential difference V is :

(A) $\lambda = \frac{h}{\sqrt{mqV}}$

(B) $\lambda = \frac{hm}{\sqrt{qV}}$

(C) $\lambda = \frac{h}{\sqrt{2mqV}}$

(D) $\lambda = 0$

22. An electron and a proton each having energy 5 eV are incident on a barrier of 10 eV high and 1 angstrom wide. The correct statement is :

(A) The electron will have greater transmission probability

(B) The proton will have greater transmission probability

(C) Both electron and proton have the same transmission probability

(D) None of them penetrate the potential

23. Which one of the following is correct in respect of an electron and a proton having the same de-Broglie wavelength of 2 angstrom ?

(A) Both have same kinetic energy

(B) The kinetic energy of the proton is more than that of the electron

(C) Both have the same velocity

(D) Both have the same momentum

24. The energy of n^{th} level of the hydrogen atom is proportional to :

(A) n

(B) n^2

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

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

25. A sample of a certain element is placed in a 0.300-T magnetic field and suitably excited. How far apart are the Zeeman components of the 450-nm spectral line of this element ?

(A) 0.00283 nm

(B) 0.0283 nm

(C) 0.283 nm

(D) No Zeeman effect takes place

26. The magnitude the angular momentum due to electron spin for spin $-\frac{1}{2}$ is :

(A) $\frac{\sqrt{3}}{2}\hbar$

(B) $\frac{\sqrt{3}}{2}\hbar^2$

(C) $\frac{\sqrt{3}}{4}\hbar^2$

(D) $\frac{\sqrt{3}}{4}\hbar$

27. The maximum number of electrons a shell can hold is (n is a principal quantum number) :

(A) $4n^2$

(B) $2n^2$

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

(D) 2n+1

28. The number N of undecayed nuclei at the time t in terms of the decay probability per unit time λ of the nuclide involved and the number N_0 of undecayed nuclei at t = 0 is :

(A) $N = N_0e^{-\lambda t}$

(B) $N = N_0e^{\lambda t}$

(C) $N = N_0e^{-\lambda t^2}$

(D) $N = N_0e^{\lambda t^2}$

29. The coordination number in case of simple cubic structure is :

(A) 12

(B) 6

(C) 2

(D) 1

30. Electronic contribution to specific heat of metals at low temperature is proportional to :

(A) $T^{\frac{3}{2}}$

(B) T^2

(C) $T^{\frac{1}{2}}$

(D) T^3

31. The valence electrons do not directly determine the following property of the metal :

(A) Electrical conductivity

(B) Thermal conductivity

(C) Shear modulus

(D) Metallic lustre

32. Electrical conductivity of a metal in terms of mass (m), charge (e), concentration (n) and relaxation time (τ) of electron is :

(A) $mne\tau$

(B) $\frac{mne}{\tau}$

(C) $\frac{ne^2\tau}{m}$

(D) $\frac{ne^2\tau^2}{m}$

33. The impurity atoms with which pure silicon should be doped to make a p-type semiconductor are :

(A) Phosphorus and boron

(B) Boron and aluminium

(C) Boron and antimony

(D) Antimony and aluminium

34. The Fermi level of an intrinsic semiconductor is pinned at the center of the band gap. The probability of occupation of the highest electron state in valence band at room temperature will be :

(A) Zero

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

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

(D) Infinity

35. The avalanche breakdown in a pn-junction is due to :

(A) Shift of Fermi level

(B) Cumulative effect of conduction band electron collisions

(C) Widening of forbidden gap

(D) None of the above

36. The depletion layer in a pn-junction diode consists of layers of :

(A) Positively charged donors on the p-side and negatively charged acceptors on the n-side

(B) Negatively charged donors on the p-side and positively charged acceptors on the n-side

(C) Positively charged donors on the n-side and negatively charged acceptors on the p-side

(D) Negatively charged donors on the p-side and positively charged acceptors on the n-side

37. If a transistor amplifier has a gain of 20dB, then the ratio of output to input power is :

(A) 100

(B) 10

(C) 20

(D) 200

38. The DC load line of an amplifier circuit :

(A) Has a positive slope

(B) Has a curvature

(C) Does not contain the Q-point

(D) Has a negative slope

39. An increase in diode voltage leads to :

(A) Increase in diode resistance

(B) Decrease in diode resistance

(C) No change in diode resistance

(D) Increase or decrease depending on the nature of diode

40. A junction field effect transistor behaves as :

(A) Voltage controlled current source

(B) Voltage controlled voltage source

(C) Current controlled voltage source

(D) Current controlled current source

41. A body of charge q starts from rest and acquires a velocity v = 0.5c. The new charge of the body is :

(A) $\frac{q}{\sqrt{1-(0.5)^2}}$

(B) $q\sqrt{1-(0.5)^2}$

(C) $q\sqrt{1-(0.5)^3}$

(D) q

42. The principle of relativity states :

(A) The Laws of Physics are same for any two non-inertial observers

(B) The Laws of Physics are not same for inertial observers

(C) The Laws of Physics are same for all inertial observers in uniform motion relative to each other

(D) No relativity exists

43. A particle of mass m released from a height h falls under gravity. Assuming that the resistance offered by air is mkv^2, where k is a constant, v the velocity of particle. The terminal speed of the particle is :

(A) $\frac{g}{k}$

(B) $\sqrt{\frac{g}{k}}$

(C) $\sqrt{gk}$

(D) $\sqrt{\frac{k}{g}}$

44. The kinetic energy of a particle continuously increases with time, then :

(A) The resultant force on the particle must be parallel to the velocity at all times

(B) The angle between force and velocity is acute all the time

(C) Its height above the ground continuously increases

(D) The angle between force and velocity is 90° always

45. A sphere of radius r and mass m rolls without slipping on a surface with speed v. The ratio of translational kinetic energy and rotational kinetic energy is :

(A) $\frac{1}{5}$

(B) $\frac{2}{5}$

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

(D) $\frac{5}{8}$

46. In the case of geostationary satellite, the :

(A) Rotation of the earth and revolution of the satellite will be in the same direction

(B) Rotation of the earth and revolution of the satellite will be in the opposite direction

(C) Angular velocity of the earth's rotation and angular velocity of revolution of the satellite will be equal and in the same direction

(D) Angular velocity of the earth's rotation and angular velocity of revolution of the satellite will be different and in the opposite direction

47. When a satellite moves around the earth, the quantity which remains constant :

(A) Angular velocity

(B) Kinetic energy

(C) Potential energy

(D) Areal velocity

48. Two particles initially at rest, move towards ea other under a mutual force of attraction. If at instant, the speed of one particle is v and speed the other particle is 2v, then the speed of the cen of mass of the system is :

(A) Zero

(B) v

(C) 1.5v

(D) 3v

49. The electric field intensity on the surface charged conductor is :

(A) Zero

(B) Directed normally to the surface

(C) Directed tangentially to the surface

(D) Directed at 45° to the surface

50. For a particle executing simple harmonic mo then :

(A) Time average of the total energy is p kinetic energy

(B) Time average of the total energy is p potential energy

(C) Time average of potential energy is sa time average of kinetic energy

(D) Time average of potential energy is not as time average of kinetic energy

51. A sphere of radius R has a charge density ρ which varies with distance as $\rho = \alpha\sqrt{r}$, α is a constant. The electric field at a distance r < R varies with r as :

(A) $E \propto \frac{1}{\sqrt{r}}$

(B) $E \propto \sqrt{r}$

(C) $E \propto r^{\frac{3}{2}}$

(D) $E \propto r^{2}$

52. A charge q sits at one of the corners of a cube of side a. The flux through one side of this cube is :

(A) Zero

(B) $\frac{q}{24\epsilon_0}$,

(C) $\frac{q}{16\epsilon_0}$

(D) $\frac{q}{2\epsilon_0}$

53. Two large metal plates each of area A are held a small distance d apart. The electric field is :

(A) Zero everywhere

(B) E = 0 between the plates and $E = \frac{\sigma}{\epsilon_0}$ outside the plates

(C) E = 0 outside the plates and $E = \frac{\sigma}{\epsilon_0}$ between the plates

(D) $E = \frac{\sigma}{\epsilon_0}$ everywhere

54. If magnetic field $\vec{B} = \nabla \times \vec{A}$, $\vec{A}$ being the vector potential, then for constant magnetic field we have :

(A) $\vec{A} = \frac{1}{2}(\vec{B} \times \vec{\Delta})$

(B) $\vec{A} = \frac{1}{2}(\vec{B} \times \vec{r})$

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

(D) 0

55. A hollow sphere of radius R has a charge +q on its surface. If the charge on the sphere is doubled and its radius is halved, the energy associated with the electric field :

(A) Increases eight times

(B) Increases four times

(C) Remains same

(D) Decreases four times

56. Electric field inside a conductor carrying surface charge density σ is :

(A) Zero

(B) $\frac{\sigma}{\epsilon_0}$

(C) $\frac{\sigma}{2\epsilon_0}$

(D) $\sqrt{\frac{\sigma}{\epsilon_0}}$

57. In an electromagnetic wave, the direction of the magnetic field is :

(A) Parallel to the electric field

(B) Perpendicular to the electric field

(C) Completely random

(D) Antiparallel to the Poynting vector

58. A free electron is placed in the path of a plane electromagnetic wave. The electron will start moving :

(A) Along the electric field

(B) Along the direction of magnetic field

(C) Along the direction of propagation of wave

(D) Cannot move at all

59. The vector potential in a region is given as $\vec{A} = -y\hat{i} + 2x\hat{j}$. The associated magnetic field $\vec{B}$ is :

(A) $\hat{i} + \hat{k}$

(B) $3\hat{k}$

(C) $-\hat{i} + 2\hat{j}$

(D) $-\hat{i} + \hat{j} + \hat{k}$

60. If charge on a parallel plate capacitor is $q = q_0 \sin \omega t$, then the displacement current is :

(A) $\omega q_0 \cos \omega t$

(B) $\frac{q_0}{\omega} \cos \omega t$

(C) $-\frac{q_0}{\omega} \cos \omega t$

(D) $-\omega q_0 \cos \omega t$

Sr. No. ....

ENTRANCE TEST-2021

SCHOOL OF PHYSICAL & MATHEMATICAL SCIENCES

PHYSICS

Question Booklet Series **A**

Total Questions : 60

Time Allowed : 70 Minutes

Roll No. : | | | | | | |

Instructions for Candidates :

1. Write your Entrance Test 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.

1. Choose the incorrect statement :

(A) If total linear momentum of a system of particles is zero, the angular momentum of the system is the same around all origins

(B) Even if total linear momentum of a system of particles is not zero, the angular momentum of the system is same around all origins

(C) If the total force on a system of particles is zero, the torque on the system is the same around all origins

(D) When a rigid body rotates around an axis, every particle in the body remains at a fixed distance from the axis

2. If F is the time-dependent force F = A – Bt, where A and B are positive constants, the velocity v(t) in terms of A, B, m (mass), v_0(initial velocity) and x_0(initial position) is given by :

(A) $v(t) = v_0 + At/m - B t^2/2m$

(B) $v(t) = v_0 + At^2/m - B t/2m$

(C) $v(t) = v_0 + B t^2/2m$

(D) $v(t) = v_0 - B t^2/2m$

3. How far approximately will a small boat move, when a man with mass 64 kg moves from back to front of the boat ? Given that length of boat is 2.7 m, its mass is 92 kg. (Water resistance and tilt of the boat is negligible)

(A) 1.03 m

(B) 1.40 m

(C) 2.74 m

(D) 1.10 m

4. The Michelson–Morley experiment was designed to show :

(A) The difference in the speed of light between directions parallel and perpendicular to the Earth's motion

(B) The speed of light in vacuum is not invariant

(C) That Galilean transformation equations are valid for the speed of light to be invariant

(D) None of the above

5. An astronaut sees two spaceships flying apart with speed 0.99c. The speed of one spaceship as viewed by the other nearly is :

(A) 0.99995c

(B) c

(C) 0.95555c

(D) 0 c

6. A particle moves in a circular orbit with the potential energy $U(r) = -A/r^n$, where $A > 0$. For what values of 'n' are the circular orbits stable :

(A) $n > 2$

(B) $n \leq 2$

(C) Only for $n = 2$

(D) Only for $n = 1$

7. A particle of mass 'm' is located in the y-z plane at x = 0, y = 3, z = 3. Its moment and products of inertia relative to the origin written in the form of an Inertia matrix are :

(A) $I = 9m\begin{bmatrix} 2 & 0 & -1 \\ 0 & 1 & 0 \\ -1 & 0 & 1 \end{bmatrix}$

(B) $I = 9m\begin{bmatrix} -1 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix}$

(C) $I = m\begin{bmatrix} 2 & 0 & -1 \\ 0 & 1 & 0 \\ -1 & 0 & 1 \end{bmatrix}$

(D) $I = m\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 0 & -1 \end{bmatrix}$

8. A marble of mass 0.1 kg and radius 0.25 m is rolled up a plane of angle 30°. If the initial velocity of the marble is 2 m/s, the distance 'd' it travels up the plane before it begins to roll back down is equal to :

(A) 4 m

(B) 4/5 m

(C) 4/7 m

(D) 4/9 m

9. A thin sheet of mass M is in the shape of an equilateral triangle with side L. The moment of inertia around an axis through a vertex, perpendicular to the sheet is :

(A) 5/7 ML^2

(B) 5/12 ML^2

(C) 5/9 ML^2

(D) 1/2 ML^2

10. The graph of the function as shown in Fig.1 is best described by :

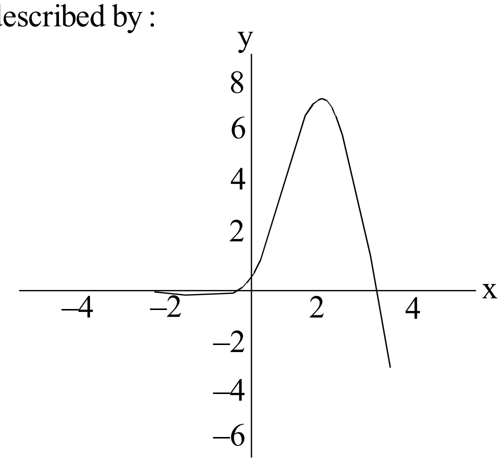


Fig. 1

(A) $e^{x} \cos(x)$

(B) $e^{-x} \cos(x)$

(C) $e^{x} \sin(x)$

(D) $e^{-x} \sin(x)$

11. If a force F is derivable from a potential function V(r), where r is the distance from the origin of the coordinate system, it follows that :

(A) $\nabla \times F = 0$

(B) $\nabla \cdot F = 0$

(C) $\nabla V = 0$

(D) $\nabla^2 V = 0$

12. Which of the following expressions for a vector potential $\vec{A}$ does represent a uniform magnetic field of magnitude B along the z-direction ?

(A) $\vec{A} = x\,B\hat{j}$

(B) $\vec{A} = \frac{1}{2}xB\hat{i} + \frac{1}{2}y\,B\hat{j}$

(C) $\vec{A} = -\frac{1}{2}yB\hat{i} + \frac{1}{2}xB\hat{j}$

(D) $\vec{A} = -zB\hat{i}$

13. For a particle moving in a central force field, which one of the following statements is correct ?

(A) The motion is restricted to a plane due to the conservation of angular momentum

(B) The motion is restricted to a plane due to the conservation of energy only

(C) The motion is restricted to a plane due to the conservation of linear momentum

(D) The motion is not restricted to a plane

14. The magnetic field of a dipole can be written in the following coordinate free form :

(A) $\frac{3\mu_0}{4\pi r^2}\{[\vec{m}\cdot\hat{r}]\,\hat{r}-\vec{m}\}$

(B) $\frac{\mu_0}{4\pi r^3}\{[\vec{m}\cdot\hat{r}]\,\hat{r}-\vec{m}\}$

(C) $\frac{3\mu_0}{4\pi r^3}\{[\vec{m}\cdot\hat{r}]\,\hat{r}-\vec{m}\}$

(D) $\frac{1}{4\pi r^2}\{[\vec{m}\cdot\hat{r}]\,\hat{r}-\vec{m}\}$

15. Which of the following statement is incorrect ?

(A) Maxwell's equations in free space are not invariant under Lorentz transformation

(B) Maxwell's equations in free space are invariant under Lorentz transformation

(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

16. A square loop of wire (side a) lies on a flat surface, a distance s from a very long straight wire, which carries a current I as shown in Fig. 2. The flux of B through the loop is :

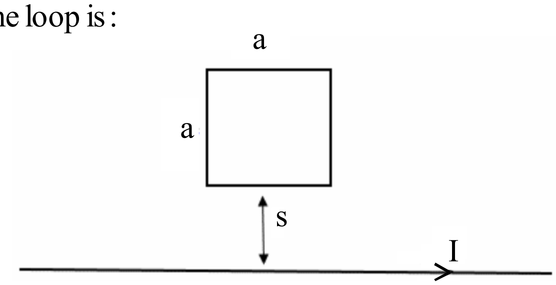


Fig.2

(A) $\frac{\mu_0}{4\pi}\,Ia\,ln\left(\frac{s+a}{s}\right)$

(B) $\frac{\mu_0}{4\pi}\,Ia\,ln\left(\frac{s+a}{s^2}\right)$

(C) $\frac{\mu_0}{2\pi}\,Ia\,ln\left(\frac{s+a}{s}\right)$

(D) $\frac{\mu_0}{4\pi}\,Ia\,ln\left(\frac{s^2+a^2}{s}\right)$

17. A stationary iron sphere of radius R carries a charge Q and a uniform magnetization M. The magnitude of angular momentum stored in the electromagnetic fields is :

(A) $\frac{2}{9}\,\mu_0 M\,Q\,R^2$

(B) $\frac{2}{9}\,\mu_0 M\,Q$

(C) $\frac{2}{9}\,\mu_0 M\,Q\,R$

(D) $\frac{1}{2}\,\mu_0 M\,R^2$

18. The electromagnetic theory suggests that the electric vector of an electromagnetic wave suffers a sudden phase change of 180° on reflection from the plane reflecting surface but the magnetic vector suffers :

(A) A phase change of 180°

(B) A phase change of 90°

(C) A phase change of 270°

(D) No phase change

19. In free space, the Poisson equation for electrostatics becomes :

(A) The Maxwell's equation $\nabla \cdot B = 0$

(B) The Laplace equation

(C) The steady state continuity equation

(D) The Ampere's circuital law

20. For an anisotropic dielectric media, the relative permittivity is a :

(A) Vector quantity

(B) Scalar quantity

(C) Tensor quantity

(D) None of the above because relative permittivity is only defined for isotropic media

21. Two ideal polyatomic gases of degrees of freedom f_1 and f_2 at temperatures T_1 and T_2 are mixed so that there is no loss of energy. If the masses and the number of molecules of the two gases are m_1, m_2 and n_1, n_2, respectively, the temperature of the mixture will be :

(A) $\dfrac{n_1f_1T_1 - n_2f_2T_2}{n_1f_1 + n_2f_2}$

(B) $\dfrac{n_1f_1T_1 + n_2f_2T_2}{n_1f_1 + n_2f_2}$

(C) $\dfrac{n_1f_1T_1 + n_2f_2T_2}{n_1f_1 - n_2f_2}$

(D) $\dfrac{n_1T_1 + n_2T_2}{n_1f_1 + n_2f_2}$

22. The van der Waal's equation of state for an ideal gas is given by :

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

The critical constants for such a gas are given as :

(A) $V_C = \frac{2}{3}b,\ p_c = \frac{a}{27b^2},\ T_C = \frac{8a}{27Rb^2}$

(B) $V_C = \frac{1}{3}b,\ p_c = \frac{a}{3b^2},\ T_C = \frac{8a}{27Rb^2}$

(C) $V_C = 3b,\ p_c = \frac{a}{27b^2},\ T_C = \frac{8a}{27Rb}$

(D) $V_C = \frac{1}{2}b,\ p_c = \frac{a}{3b^2},\ T_C = \frac{8a}{Rb^2}$

23. Which of the following shows the correct relationship between the thermodynamical variables ?

(A) $\left(\frac{\partial T}{\partial p}\right)_V \left(\frac{\partial S}{\partial V}\right)_p = \left(\frac{\partial T}{\partial V}\right)_p \left(\frac{\partial S}{\partial p}\right)_V$

(B) $\left(\frac{\partial T}{\partial p}\right)_V \left(\frac{\partial S}{\partial V}\right)_p = -\left(\frac{\partial T}{\partial V}\right)_p \left(\frac{\partial S}{\partial p}\right)_V$

(C) $\left(\frac{\partial p}{\partial T}\right)_S \left(\frac{\partial S}{\partial V}\right)_p = \left(\frac{\partial p}{\partial S}\right)_T \left(\frac{\partial V}{\partial T}\right)_S$

(D) $\left(\frac{\partial p}{\partial T}\right)_S \left(\frac{\partial S}{\partial V}\right)_p = -\left(\frac{\partial p}{\partial S}\right)_T \left(\frac{\partial V}{\partial T}\right)_S$

24. The approximate number of modes of standing waves in a chamber of volume 100 cm^3 in the frequency range 4×10^{14} Hz to 4.001×10^{14} Hz are: (where $c = 3 \times 10^8$m/s) :

(A) 1.5×10^{14}

(B) 1.5×10^{12}

(C) 1.5×10^{10}

(D) 1.5×10^{14}

25. Which of the following statement is not correct ?

(A) Stefan-Boltzmann law states that the total rate of emission of radiant energy by a body per unit area is related to energy density as fourth power of its temperature

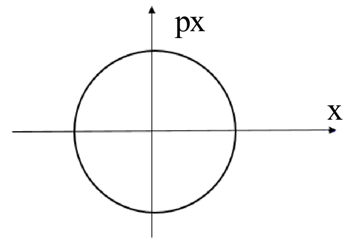
(B) Rayleigh-Jeans formula for the distribution of energy treats blackbody radiation as standing electromagnetic waves which arise due to multiple reflections at the walls of the enclosure and each mode

(C) According to Planck, blackbody radiation chamber is filled up not only with radiation but also with the molecules of a perfect gas, which exchange energy via resonators of molecular dimensions

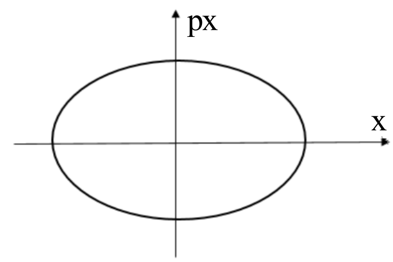
(D) According to Rayleigh-Jeans formula the energy density of Blackbody spectrum within the wavelength range λ and $\lambda + d\lambda$ is directly proportional to the fourth power of the wavelength

26. Which of the following represents the phase space of a linear harmonic oscillator ?

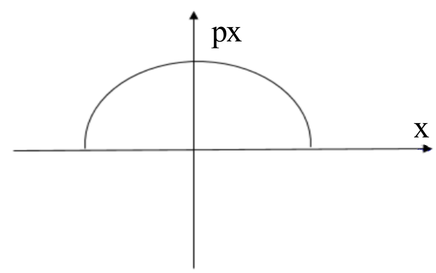
(A)



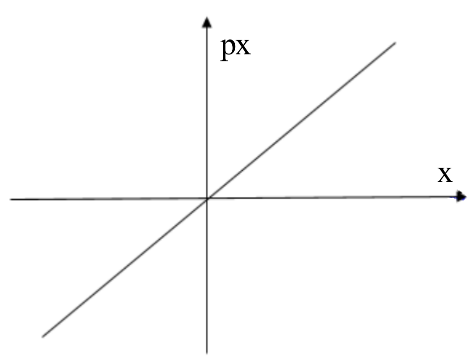
(B)



(C)



(D)



27. There are two identical particles and each particle can be in one of the three possible quantum states of energies 0, ε and 3ε. The number of microstates of the system for Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics are respectively :

(A) 6,6,3

(B) 3,6,3

(C) 3,3,6

(D) 6,6,6

28. For a Fermi–Dirac system, the thermodynamic probability of distributing N indistinguishable particles into various energy states subject to Pauli principle is given by :

(A) $\Pi_i \frac{g_i!}{n_i!(g_i+n_i)!}$

(B) $\Pi_i \frac{n_i!}{g_i!(g_i-n_i)!}$

(C) $\Pi_i \frac{(n_i+g_i-1)!}{n_i!(g_i-1)!}$

(D) $\Pi_i \frac{g_i!}{n_i!(g_i-n_i)!}$

Where n_i represents the number of particle in ith state and g_i, the degeneracy of the state.

29. The coefficient of viscosity for a gas having velocity gradient in a direction normal to the direction of mass motion is given by :

(A) $\eta = \frac{1}{3}m^2n\bar{v}\lambda$

(B) $\eta = \frac{1}{3}mn\bar{v}\lambda$

(C) $\eta = \frac{1}{3}mn^2\bar{v}\lambda$

(D) $\eta = \frac{1}{3}mn\bar{v}\lambda^2$

where m is the molecular mass, $\bar{v}$ is the average speed and λ is the mean free path of a molecule.

30. Choose the incorrect statement :

(A) A real gas shows deviation from perfect gas behaviour at high pressures

(B) The temperature above which a gas cannot be liquefied by applying pressure is known as critical temperature

(C) Every gas undergoing Joule–Thomson expansion at a temperature below the inversion temperature shows cooling

(D) van der Waals' equation is inconsistent with the statement that all gases approach ideal gas behaviour at low pressures

31. Fig.3 shows the p-V diagram of an ideal engine. Assuming all the processes to be quasi-static and heat capacity at constant pressure, C_p to be constant. Then the efficiency of such an ideal engine is given by :

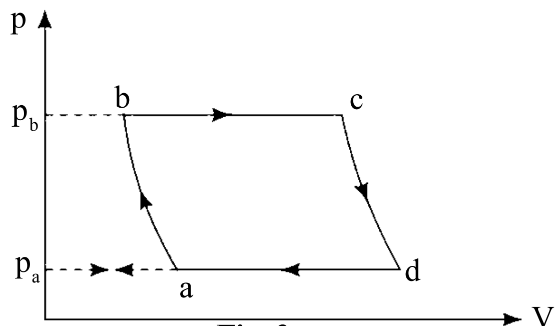


Fig. 3

(A) $\eta = 1 - \left(\frac{p_a}{p_b}\right)^{\frac{1}{\gamma}}$

(B) $\eta = 1 - \left(\frac{p_a}{p_b}\right)^{\frac{\gamma-1}{\gamma}}$

(C) $\eta = 1 - \left(\frac{p_a}{p_b}\right)^{\gamma}$

(D) $\eta = 1 - \left(\frac{p_a}{p_b}\right)^{\frac{1}{\gamma-1}}$

32. Which of the following equations correctly represents the change in the entropy of an ideal gas ?

(A) $\Delta S = C_V \, ln\left(\frac{T_2}{T_1}\right) + R \, ln\left(\frac{V_2}{V_1}\right)$

(B) $\Delta S = C_p \, ln\left(\frac{T_2}{T_1}\right) - R \, ln\left(\frac{p_2}{p_1}\right)$

(C) $\Delta S = C_p \, ln\left(\frac{V_2}{V_1}\right) + C_V \, ln\left(\frac{p_2}{p_1}\right)$

(D) All the above

33. Which of the following statements is CORRECT for a common emitter amplifier circuit ?

(A) There is 180° phase shift between input and output voltages

(B) Both p-n junctions are forward biased

(C) There is 90° phase shift between input and output voltages

(D) There is no phase shift between input and output voltages

34. For an ideal Fermi gas in three dimensions, the Fermi energy ε_f is proportional to n^α, where n is the number of electrons per unit volume , then α is equal to :

(A) 2/3

(B) 1/3

(C) 1/2

(D) 2

35. The order of magnitude of the energy gap of a typical semiconductor is :

(A) 1 MeV

(B) 10 eV

(C) 1 eV

(D) 10^{-3} eV

36. If the group velocity of waves in a certain medium is v_g , while its phase velocity is v, then which of the following is not correct :

(A) For a normal dispersive medium, $v > v_g$

(B) For a non-dispersive medium, $v = v_g$

(C) For an anomalously dispersive medium, $v < v_g$

(D) For a normal dispersive medium, $\frac{dv}{d\lambda} < 0$

where λ represents the wavelength.

37. Stern-Gerlach experiment verified the :

(A) Quantization of angular momentum

(B) Existence of electron spin

(C) That atoms can align themselves in a magnetic field only in a few directions

(D) All the above

38. An atom is placed in a magnetic field B. The change in the energy of the atom is :

(A) $\Delta E = -g(L + 2S) . B$

(B) $\Delta E = -g(2L + S) . B$

(C) 0

(D) $\Delta E = -g(L + S) . B$

39. The average power of a harmonic wave, $y = A \sin (kx - \omega t)$, propagating with velocity, v, along a stretched string having mass per unit length, μ, is given by :

(A) $\mu\omega^2 A^2 v \sin^2(kx - \omega t)$

(B) $\mu\omega^2 A^2 v \cos^2(kx - \omega t)$

(C) $\frac{\mu}{2}\omega^2 A^2 v$

(D) Zero

40. Consider a standing wave, $y = 2A \cos(\omega t) \sin (kx)$ with 'n' antinodes, on a string of length L. If $k = \frac{n\pi}{L}$, then which of the following is not correct :

(A) The average energy of the wave is directly proportional to A^2

(B) The average energy of the wave is directly proportional to n^2

(C) The average energy of the wave is inversely proportional to L

(D) The average energy of the wave is inversely proportional to n^2

41. Which of the following statement is not correct ?

(A) The interference pattern in Young's two slit experiment is based on the principle of division of wave front

(B) The interference pattern in Michelson interferometer is based on the principle of division of amplitude

(C) A Michelson interferometer is basically a multi-wave interferometer

(D) Two-wave interference is characterized by a sinusoidal variation of light intensity with phase difference between the interfering waves

42. When a plane wave is incident normally on N parallel slits, the intensity distribution according to the Fraunhofer diffraction is given by :

(A) $I = I_0 \frac{\sin^2 \beta}{\sin \gamma} \sin^2 N\gamma$

(B) $I = I_0 \frac{\sin^2 \beta}{\beta^2} \frac{\sin^2 N\gamma}{\cos^2 \gamma}$

(C) $I = I_0 \frac{\sin^2 \beta}{\beta^2} \frac{\sin^2 N\gamma}{\sin^2 \gamma}$

(D) $I = I_0 \frac{\sin^2 \beta}{\beta^2} \cos^2 \gamma$

where, $\beta = \frac{\pi b \sin \vartheta}{\lambda}$ and $\gamma = \frac{\pi d \sin \vartheta}{\lambda}$, and λ is the wavelength ϑ, is the angle of diffraction 'b' represents the width of each slit and 'd' is the separation between two slits.

43. Consider the following statements :

(1) In the process of diffraction from a circular aperture, if the source of light is at a finite distance from the diffracting aperture, then the wave fronts falling on the aperture are spherical wave fronts.

(2) Fresnel type of diffraction is defined such that distance between the source or the observation screen or both of them are at finite distances from the diffracting aperture.

(3) 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 Fresnel type of diffraction.

(4) If the source of light is at a finite distance from the diffracting aperture, then the wave fronts falling on the aperture or reaching the screen will be plane wave fronts.

Which of the above statement/s are true ?

(A) All the statements from (1) to (4) are true

(B) Only the statement (2) is true

(C) Only the statements (1) and (2) are true

(D) None of the above

44. X rays of wavelength 0.24 nm are Compton-scattered and the scattered beam is observed at an angle of 60^o relative to the incident beam. The energy of the scattered X-ray photons is :

(A) 5.14 keV

(B) 514 eV

(C) 5141 keV

(D) 5.1×10^4 keV

45. Consider the following three experiments :

(a) The x component of the position of an electron is measured to within $\pm\Delta x$ and simultaneously the x component of its momentum is measured to within $\pm\Delta$ px

(b) The x component of the position of an electron is measured to within $\pm\Delta x$ and then later the x component of its momentum is measured to within $\pm\Delta px$

(c) The x component of the position of an electron is measured to within $\pm\Delta x$ and simultaneously the y component of its momentum is measured to within $\pm\Delta$ py.

In which of these cases does the Uncertainty Principle NOT impose a limitation on the outcome of the experiment ?

(A) (a) only

(B) (a) and (b) only

(C) (b) and (c) only

(D) (c) only

46. A beam of particles is incident from the negative x direction on a potential energy step at $x = 0$. When $x < 0$, the potential energy of the particles is zero and for $x > 0$ the potential energy has the constant positive value U_0. In the region $x < 0$, the particles have a kinetic energy K that is smaller than U_0. What is the form of the wave function in the region $x > 0$?

(A) $Ae^{kx} + Be^{-kx}$

(B) $Ae^{ikx} + Be^{-ikx}$

(C) Ae^{ikx}

(D) Ae^{-ikx}

47. The list of excited states to which the 4p state can make downward transitions are :

(A) $4p \rightarrow 3s$, $4p \rightarrow 4s$, $4p \rightarrow 2s$, $4p \rightarrow 1s$

(B) $4p \rightarrow 3s$, $4p \rightarrow 2s$, $4p \rightarrow 1s$, $4p \rightarrow 3d$

(C) $4p \rightarrow 3s$, $4p \rightarrow 4s$, $4p \rightarrow 2s$, $4p \rightarrow 4d$

(D) $4p \rightarrow 3s$, $4p \rightarrow 2s$, $4p \rightarrow 1s$, $4p \rightarrow 2d$

48. For a molecule, there are three different types of excited states : electronic, vibrational and rotational. Put these in increasing order according to the amount of energy generally required for each type of excitation :

(A) Vibrational, electronic, rotational

(B) Vibrational, rotational, electronic

(C) Electronic, vibrational, rotational

(D) Rotational, vibrational, electronic

49. The ratio of Fermi energy of a metal at temperature T, $\varepsilon_f(T)$, to its Fermi energy at absolute zero, $\varepsilon_f(0)$, is approximately equal to :

(A) 1

(B) $\frac{\pi^2}{12} kT$

(C) $\left[1 - \frac{\pi^2}{12}\left(\frac{kT}{\varepsilon_f(0)}\right)\right]$

(D) $\left[1 - \frac{\pi^2}{12}\left(\frac{kT}{\varepsilon_f(0)}\right)^2\right]$

50. A certain insulator has an energy gap of 6.0 eV. A visible light in the wavelength range 400 to 700 nm falls on this material. Now choose the correct statement :

(A) The material will strongly absorb the visible light

(B) The material will not absorb the visible light

(C) The material shines when the light falls on it

(D) The material will strongly absorb the infrared light

51. At the lowest temperatures, the molar heat capacity of metals can be explained primarily by the application of :

(A) The equipartition theorem

(B) Fermi-Dirac statistics of electrons

(C) Bose-Einstein statistics of vibrating atoms

(D) Maxwell-Boltzmann statistics

52. The temperature at which the lattice and electronic heat capacities of copper become equal to each other (Take Debye temperature, T_D = 343 K and Fermi energy = 7.03 eV) :

(A) 300 K

(B) 273 K

(C) 4.2 K

(D) 3.2 K

53. Which of the following statement is not correct regarding the Nuclear Fusion ?

(A) Nuclei produced in the reaction are usually highly radioactive

(B) Energy release can be as large as several MeV per reacting nucleon

(C) It is usually necessary to overcome a Coulomb barrier for the reaction to occur

(D) Reacting nuclei come from commonly available chemical elements

54. In the decays and reactions of elementary particles, which of the following conservation laws is not followed strictly ?

(A) In any process, the lepton numbers for electron-type leptons, muon-type leptons and tau-type leptons must each remain constant

(B) In any process, the total baryon number must remain constant

(C) In processes governed by the strong or electromagnetic interactions, the total strangeness must remain constant

(D) In processes governed by the weak interaction, the strangeness must remain constant

55. In a p-n junction at room temperature, the ratio between the current with a forward bias of 2 V to the current with a forward bias of 1V is (approximately) :

(A) 1.7×10^{19}

(B) 1.7×10^{17}

(C) 2.1×10^{15}

(D) 2.1×10^{19}

56. Choose the incorrect statement :

(A) The small-signal hybrid-pi model applies to transistors operating in the forward-active mode in linear amplifier circuits

(B) The cut-off frequency of a transistor is the frequency at which the magnitude of the common-emitter current gain becomes equal to 100

(C) The frequency response of a transistor amplifier is a function of the emitter–base junction capacitance charging time

(D) When a transistor is biased in the forward-active mode of operation, the current at one terminal of the transistor (collector current) is controlled by the voltage applied across the other two terminals of the transistor (base–emitter voltage)

57. A typical transistor with $\beta = 100$, has a base-to-collector leakage current, I_{CBO}, of 5μA. If the transistor is connected for common-emitter operation then the collector current for $I_B = 40\ \mu A$:

(A) 4.5 mA

(B) 5.4 mA

(C) 1.5 mA

(D) 4.5 μA

58. The bandwidth of an amplifier is determined by :

(A) The mid range gain

(B) The critical frequencies

(C) The input capacitance

(D) The roll-off rate

59. A certain common emitter amplifier has a voltage gain of 100. If the emitter bypass capacitor is removed :

(A) The circuit will become unstable

(B) The voltage gain will decrease

(C) The voltage gain will increase

(D) The Q-point will shift.

60. A Voltage-divider bias :

(A) Cannot be independent of β_{dc}

(B) Is not widely used

(C) Requires fewer components than all the other methods

(D) Can be essentially independent of β_{dc}

ROUGH WORK

ROUGH WORK

Sr. No. 083

ENTRANCE TEST-2020

SCHOOL OF PHYSICAL & MATHEMATICAL SCIENCES

PHYSICS

Question Booklet Series **C**

Total Questions : 60

Time Allowed : 70 Minutes

Roll No. :

Instructions for Candidates :

1. Write your Entrance Test 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.

1. A box contains 6 balls that could be either red or blue. How many different microstates satisfy the macrostate of exactly 3 of the balls being red ?

(A) 3

(B) 6

(C) 12

(D) 20

2. An electron is moving with a speed of 0.6 C. The phase velocity of its de Broglie waves is :

(A) 0.71 C

(B) 0.82 C

(C) 0.94 C

(D) 1.67 C

3. For a dynamical system of N particles, the phase-space is :

(A) 3N – dimensional consisting of positions of the N particles

(B) 4N – dimensional consisting of positions of the N particles and time

(C) 6N – dimensional consisting of positions and momenta of the N particles

(D) Infinite dimensional as it is a Hilbert space

4. If the two input waveforms of equal frequency and amplitude with 90 degree phase difference is applied to the CRO, then the Lissajous patterns obtained will be :

(A) A straight line

(B) A circle

(C) An ellipse

(D) A hyperbola

5. In an interference pattern, the wavelength and frequency are :

(A) greater in regions of constructive interference than in regions of destructive interference

(B) unchanged in regions of destructive interference but greater in regions of constructive interference

(C) the same in both the regions of constructive interference and the regions of destructive interference

(D) unchanged in regions of destructive interference but smaller in regions of constructive interference

6. In the Michelson interferometer experiment, if one of the mirrors is moved by a distance of 0.06 mm, 240 fringes cross the field of view. The corresponding wavelength is :

(A) 1440 Å

(B) 5000 Å

(C) 14400 Å

(D) 5 mm

7. If n is a natural number and λ is the wavelength of light, then the radius of the nth half period zone is proportional to :

(A) $n^2\lambda$

(B) n/λ

(C) λ/n

(D) $\sqrt{n\lambda}$

8. In an interference pattern formed by two coherent sources, the intensities of the individual wave are 9I and 4I. The maximum and minimum intensities are respectively :

(A) 3I and 2I

(B) 13I and 5I

(C) 49I and 16I

(D) 25I and I

9. Which of the following quantities cannot be calculated from the Hall effect experiment ?

(A) Mobility of charge carriers

(B) Number density of charge carriers

(C) Type of the semiconductor

(D) Energy band gap of the semiconductor

10. A Fraunhofer diffraction pattern is produced on a screen located 2 m from a single slit. If a light source of wavelength 200 nm is used and the distance from the center of the central bright fringe to the first dark fringe is 1 mm, what is the slit width ?

(A) 4 cm

(B) 4 mm

(C) 0.4 mm

(D) 0.04 mm

11. If plane-polarized light is sent through two polarizers, the first polarizer at 45° to the original plane of polarization and the second polarizer at 90° to the original plane of polarization, what fraction of the original polarized intensity gets through the last polarizer ?

(A) 0

(B) 0.125

(C) 0.25

(D) 0.50

12. Energy of the second excited state (n=3) of H atom is –1.51 eV. The energy of the first excited state of the H atom is then :

(A) –3.4 eV

(B) –13.6 eV

(C) –4.53 eV

(D) –6.04 eV

13. The de Broglie wavelength of a 100 eV electron is 10^{-10} Å. The wavelength for a 0.40 keV electron will be :

(A) 2×10^{-9} Å

(B) 5×10^{-9} Å

(C) 2×10^{-11} Å

(D) 5×10^{-11} Å

14. $\psi(x) = \exp\left(-\frac{x^2}{2}\right)$ is an eigen function of the operator $\hat{A} = \frac{\partial^2}{\partial x^2} - x^2$, the corresponding eigen value is :

(A) 1/4

(B) –1/2

(C) –2

(D) –1

15. The ground state of the harmonic oscillator is described by the wavefunction $\psi(x) = A \exp\left(-\frac{x^2}{2}\right)$, where A is the normalization constant. The expectation values $\langle x \rangle$ and $\langle P_x \rangle$ in this state are respectively :

(A) 0, 0

(B) A/2, 0

(C) 0, A/2

(D) A/2, A/4

16. Stern-Gerlach experiment gives experimental verification of :

(A) Quantization of energy of atom

(B) Orbital motion of electron

(C) Electron spin

(D) Sommerfeld model of atom

17. An element of atomic number Z decays radioactively to an element of atomic number (Z–1). This can happen on the emission of :

(A) An alpha particle

(B) An alpha particle and a beta particle

(C) A beta particle

(D) A neutron and a beta particle

18. When you write the primitive translational vectors of the reciprocal lattice in terms of the primitive translational vectors of the direct lattice, you see a common denominator $\vec{a}.(\vec{b} \times \vec{c})$ in all the primitive translational vectors of the reciprocal lattice. What is $\vec{a}.(\vec{b} \times \vec{c})$?

(A) This is the reciprocal of the direct translation vectors

(B) This is the volume of the primitive unit cell in the direct lattice

(C) The first Brillion Zone

(D) The translational vector that governs the transformation from direct lattice to reciprocal lattice

19. The interplanar spacing for a (321) plane in a simple cubic lattice whose lattice constant is a is :

(A) $a/\sqrt{6}$

(B) $6a/\sqrt{14}$

(C) $a/\sqrt{14}$

(D) $a/2\sqrt{6}$

20. According to the Einstein and Debye theories of specific heat of solids, at high temperatures the specific heat in terms of the universal gas constant R is :

(A) $C_v = 3R$ and $\frac{2}{3}R^2$ respectively

(B) $C_v = 2R^2$ and $\frac{2}{3}R$ respectively

(C) $C_v = 3R$ in both cases

(D) $C_v \propto R$ and R^3 respectively

21. The band gap of an insulator that absorbs electromagnetic radiation of all wavelengths below 3000 Å is ($h = 6.625 \times 10^{-34}$ Js) :

(A) 6.9 eV

(B) 19.8 eV

(C) 9.6 eV

(D) 4.1 eV

22. If there are p atoms in the primitive cell, the phonon dispersion relation will have :

(A) 3p optical phonon branches

(B) (p–3) optical phonon branches

(C) 3(p–1) optical phonon branches

(D) 2p acoustical phonon branches

23. In a pn junction, when a positive voltage is applied to the p region with respect to the n region, the Fermi level in the p region is now :

(A) lower than that in the n region and the total potential barrier is reduced

(B) lower than that in the n region and the total potential barrier is increased

(C) higher than that in the n region and the total potential barrier is reduced

(D) higher than that in the n region and the total potential barrier is increased

24. In an n-channel JFET, after the pinch-off, the drain current :
(A) decreases linearly with the increase in drain voltage
(B) increases exponentially with the increase in drain voltage
(C) decreases exponentially with the increase in drain voltage
(D) is independent of drain voltage

25. An amplifier in which the operating point is chosen in such a way so that the output current (or voltage) is zero for more than half of an input sinusoidal signal is called :
(A) Class A amplifier
(B) Class B amplifier
(C) Class AB amplifier
(D) Class C amplifier

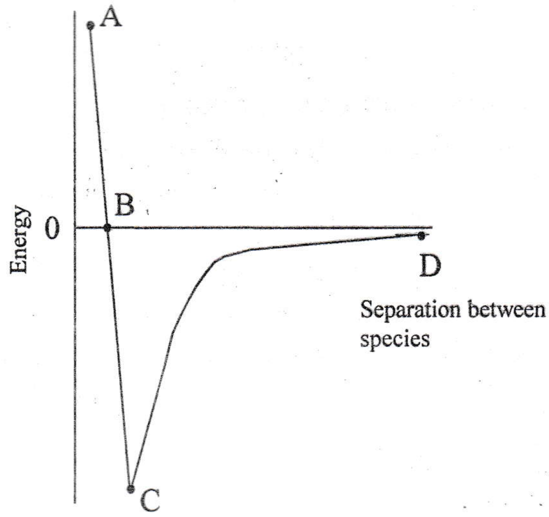
26. The drain current of an n-channel JFET having pinch off voltage $V_p = -3V$, Drain-Source saturation current $I_{DSS} = 9$ mA, and Gate-Source Voltage $V_{GS} = -1$ V, is :
(A) 2 mA
(B) 4 mA
(C) 12 mA
(D) 18 mA

27. According to Quark model, a neutron is composed of (d is down and u is up) :
(A) uuu
(B) ddd
(C) ddu
(D) uud

28. A photon incident upon a hydrogen atom ejects an electron with a kinetic energy of 10.7 eV. If the ejected electron was in the first excited state (n=2), calculate the energy of the photon.
(A) 6.30 eV
(B) 14.10 eV
(C) 24.30 eV
(D) 6.30 MeV

29. Heavy nuclei have more protons than neutrons. This is because :
(A) Neutrons are slightly heavier than protons. Heaviness makes the atom more stable
(B) Neutrons, being electrically neutral, lead to lower energy values compared to protons making the atom more stable
(C) Neutrons, being slightly heavier, lead to higher energy values compared to protons making the atom more stable
(D) If we have more protons than neutrons the atom will be positively charged. Neutrons have no such issue

30. At which of the points (A, B, C or D) on the following graph will two interacting species experience the greatest force of attraction ?



(A) At point A
(B) At point B
(C) At point C
(D) At point D

31. A spaceship at rest relative to an observer has the shape of an equilateral triangle. It passes the observer (still at rest) at relativistic speed in a direction parallel to its base. The observer will now see the spacecraft's shape take the form of :

(A) an equilateral triangle with lesser area

(B) an isosceles triangle

(C) an equilateral triangle with greater area

(D) a scalene triangle

32. Which of the statements about the four fundamental forces is incorrect ?

(A) Both the electromagnetic and gravitational forces have a $1/r^2$ dependence, but the gravitational force is much weaker

(B) The strong interaction is responsible for nuclear force

(C) The weak interaction is responsible for beta decay

(D) The strong interaction is short range and the weak interaction is long range

33. Spaceship A is moving to the right at a speed of 0.60c with respect to Earth. A second spaceship, B, moves to the left at the same speed with respect to Earth. What is the speed of A with respect to B ?

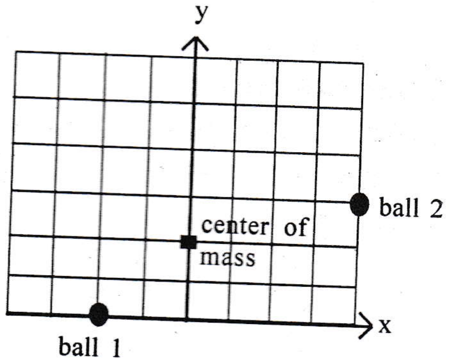
(A) 0.74c

(B) 0.88c

(C) 0.94c

(D) 1.2c

34. A system consists of three balls at different locations near the origin, as shown in the figure. Ball 1 has a mass of 2.0 kg and is located on the x-axis at $x_1 = -2.0$ m ; ball 2 has an unknown mass and is located at ($x_2 = +4.0$ m, $y_2 = +3.0$ m) ; ball 3 is somewhere on the y-axis at an unknown location, and it has a mass of 1.0 kg. The coordinates of the center-of-mass of this system are ($x_{CM} = 0$, $y_{CM} = +2.0$ m). The squares on the grid measure 1.0 m × 1.0 m. What is the mass of ball 2 ?



(A) 1 kg

(B) 2 kg

(C) 4 kg

(D) 8 kg

35. A constant net torque is applied to an object. Which one of the following will not be constant ?

(A) Angular acceleration

(B) Angular velocity

(C) Moment of inertia

(D) Center of gravity

36. If T is the orbital period of a planet and a is the length of the semimajor axis of its elliptical orbit, then according to Kepler's third law of planetary motion :

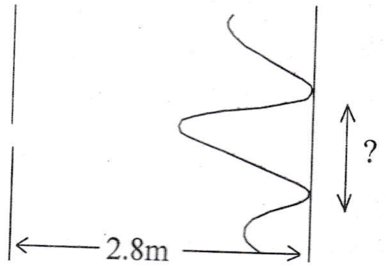
(A) $T^3 \propto a^2$

(B) $T \propto a^2$

(C) $T^2 \propto a^3$

(D) $T^2 \propto a$

37. In the below figure, a slit 0.3 mm wide is illuminated by light of wavelength 426 nm. A diffraction pattern is seen on a screen 2.8 m from the slit. What is the linear distance on the screen between the first two diffraction minima (the length shown by a question mark) on either side of the central diffraction maximum ?



(A) 795 cm

(B) 795 mm

(C) 79.5 mm

(D) 7.95 mm

38. A solid cylinder of mass M and radius R rolls down an incline without slipping. Its moment of inertia about an axis through its center of mass is $MR^2/2$. At any instant while in motion, its rotational kinetic energy about its center of mass is what fraction of its total kinetic energy ?

(A) 1/2

(B) 1/3

(C) 1/4

(D) 1/8

39. What is the nature of the below listed two forces ?

(i) $\vec{F}_1 = K(x^3\hat{y} - y^3\hat{x})$ and

(ii) $\vec{F}_2 = K(x^3\hat{x} + y^3\hat{y})$

(A) $\vec{F}_1$ is conservative, $\vec{F}_2$ is not

(B) $\vec{F}_1$ is not conservative, $\vec{F}_2$ is

(C) Both are conservative

(D) None is conservative

40. For a scalar function ϕ satisfying the Laplace equation, $\nabla\phi$ has :

(A) Zero curl and non-zero divergence

(B) Non-zero curl and zero divergence

(C) Zero curl and zero divergence

(D) Non-zero curl and non-zero divergence

41. An infinitely long thin cylindrical shell has its axis coinciding with the z-axis. It carries a surface charge density $\sigma \cos \phi$, where ϕ is the polar angle and σ is a constant. The magnitude of the electric field inside the cylinder is :

(A) $\frac{\sigma}{2\epsilon_0}$

(B) $\frac{\sigma}{3\epsilon_0}$

(C) $\frac{\sigma}{4\epsilon_0}$

(D) $\frac{\sigma}{8\epsilon_0}$

42. The modulus of the flux through a sphere of radius r that has a charge $-q$ at its centre is ϕ. Radius of the sphere is increased to 3r and the charge to $-2q$, the flux becomes :

(A) $\frac{\phi}{2}$

(B) $\frac{2\phi}{9}$

(C) $\frac{3\phi}{2}$

(D) 2ϕ

43. A fully charged parallel-plate capacitor remains connected to a battery while a dielectric is slid between the plates. Fresh measurement of the quantities Capacitance (C), Charge (Q) and Electric field (E) between the plates is made. It is found that :

(A) C increases, Q increases and E remains the same

(B) C increases, Q decreases and E remains the same

(C) C decreases, Q remains the same and E increases

(D) C increases, Q remains the same and E increases

44. A current of 10A is flowing through a circular conductor of 2.5 m radius. The magnetic field intensity at the centre of this circular conductor is ($\mu_0 = 4\pi \times 10^{-7}$Tm/A)

(A) $8\pi \times 10^{-7}$T

(B) $2\pi \times 10^{-7}$T

(C) $2\pi \times 10^{-6}$T

(D) $2\pi \times 10^{-8}$T

45. Below certain sufficiently low temperatures, which of the following materials exhibit perfect diamagnetism ?

(A) Nano materials

(B) Superconductors

(C) Semi conductors

(D) Liquid crystals

46. Read the following statements :

(i) The gradient operation turns a scalar field into a vector field

(ii) The curl operation turns a vector field into a scalar field

(iii) A vector field with zero divergence is said to be solenoidal

(iv) A vector field with zero curl is said to be irrotational

Now identify which of the statement/s is incorrect :

(A) (i) and (ii)

(B) (i) and (iii)

(C) (ii) and (iv)

(D) (ii) only

47. The current in a coil drops from 4 A to 2 A in 3 s. If the average emf induced in the coil is 6 mV, what is the self-inductance of the coil ?

(A) 1 mH

(B) 6 mH

(C) 9 mH

(D) 18 mH

48. Which of the following statements correctly describes the orientation of electric field (E), magnetic field (B) and the velocity of propagation (V) of an electromagnetic wave ?

(A) E is perpendicular to B and parallel to V

(B) E is parallel to B and perpendicular to V

(C) E is parallel to both B and V

(D) Each of the three vectors (E,B,V) is perpendicular to the other two

49. The Ampere's law written as the equation $\nabla \times B = \mu_0 J$ has a serious limitation particularly for non-steady currents. Maxwell fixed it by adding to the right hand side of this equation the term :

(A) $\mu_0 \in_0 \frac{\partial E}{\partial t}$

(B) $\mu_0 \in_0 \frac{\partial B}{\partial t}$

(C) $\mu_0 \in_0 \nabla.J$

(D) $\mu_0 \in_0 \nabla.E$

50. The electric field component of a plane electromagnetic wave travelling in vacuum is given by $\vec{E} = E_0 \cos(kz - \omega t)\hat{i}$. The Poynting Vector for the wave is :

(A) $\in_0 cE_0^2 \cos^2(kz - \omega t)\hat{k}$

(B) $2 \in_0 \frac{c}{\mu_0} E_0^2 \cos^2(kz - \omega t)\hat{j}$

(C) $\frac{c}{2 \in_0 \mu_0} E_0^2 \cos^2(kz - \omega t)\hat{j}$

(D) $\frac{1}{2\mu_0} E_0^2 \cos^2(kz - \omega t)\hat{k}$

51. In thermodynamics, the value of any thermodynamic quantity can be predicted by knowing the four fundamental thermodynamic variables. These are :

(A) Temperature, Pressure, Entropy and Specific Heat

(B) Temperature, Pressure, Volume and Number of particles

(C) Entropy, Specific Heat, Volume and Number of particles

(D) Pressure, Volume, Entropy and Fugacity

52. The specific heat at constant pressure C_p is defined in terms of enthalpy H as :

(A) $C_p = \frac{\partial H}{\partial T}$

(B) $C_p = \frac{\partial H}{\partial V}$

(C) $C_p = \frac{\partial^2 H}{\partial T^2}$

(D) $C_p = \frac{\partial^2 H}{\partial T^2} + \frac{\partial H}{\partial V}$

53. Which of the following Maxwell's (thermodynamic) relations is correct ?

(A) $\left.\frac{\partial S}{\partial T}\right|_P = -\left.\frac{\partial V}{\partial P}\right|_T$

(B) $\left.\frac{\partial V}{\partial N}\right|_P = -\left.\frac{\partial H}{\partial P}\right|_T$

(C) $\left.\frac{\partial V}{\partial T}\right|_P = -\left.\frac{\partial H}{\partial P}\right|_T$

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

54. A diatomic ideal gas is compressed adiabatically to 1/32 of its initial value. If the initial temperature of the gas is T, then its final temperature is :

(A) 32T

(B) 16T

(C) 8T

(D) 4T

55. The entropy of a three-coin system for the case in which two (of the three) coins are heads up is (k is the Boltzmann constant).

(A) k ln2

(B) k ln3

(C) k^2 ln2

(D) 2k ln2

56. A temperature change can occur in a gas as a result of a sudden pressure change over a pressure regulator or valve. This was an important observation in thermodynamics and is known as the :

(A) Seebeck effect

(B) Raman effect

(C) Joule-Thomson effect

(D) Peltier effect

57. The mean free path of molecules of a gas at pressure P and temperature T is X cm. If the pressure is doubled and the temperature is halved, the mean free path would be :

(A) 2X cm

(B) 4X cm

(C) X/2 cm

(D) X/4 cm

58. Below is given a statement of assertion (X) and a corresponding statement of reason (Y). Read these and then choose the correct option.

Assertion (X) : The ratio of the specific heats (C_p/C_v) for a diatomic gas is more than that for a monoatomic gas.

Reason (Y) : The molecules of a diatomic gas have more degrees of freedom than those of a monoatomic gas.

(A) X is correct, Y is wrong and contradicts X

(B) X is wrong, Y is correct but contradicts X

(C) Both X and Y are correct and support each other

(D) Both X and Y are incorrect and contradict each other

59. Fermi-Dirac statistics applies to systems of identical particles that are :

(A) Distinguishable, have half odd integral spin and obey the exclusion principle

(B) Indistinguishable, have half odd integral spin and obey the exclusion principle

(C) Distinguishable, have integral spin and do not obey the exclusion principle

(D) Indistinguishable, have integral spin and do not obey the exclusion principle

60. In a metal the Fermi energy describes :

(A) The mean thermal energy of the atoms at temperature T

(B) The minimum energy necessary to remove an electron from the metal

(C) The highest occupied energy state of a free electron at zero temperature

(D) The energy necessary to break the bonds between the metal atoms

1. A uniform rod of length ℓ and mass M is at rest on a horizontal frictionless table. An impulse of magnitude I is applied to one end of the rod and perpendicular to it. The velocity of the center of mass is :

(A) $\frac{I}{M}$

(B) $\frac{2I}{M}$

(C) $\frac{I}{2M}$

(D) $\frac{3I}{M}$

2. 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) $v = \sqrt{D\mu}$

3. A body of charge q starts from rest and acquires a velocity v = 0.5 c. The new charge of the body is :

(A) $\frac{q}{\sqrt{1-(0.5)^2}}$

(B) $q\sqrt{1-(0.5)^2}$

(C) $q\sqrt{1-(0.5)^3}$

(D) q

4. If the Galilean transformation were correct, then the abberation angle would be given by :

(A) $v = c\tan\theta$

(B) $v = c\cos\theta$

(C) $v = c\sin\theta$

(D) All of above

5. If a planet were suddenly stopped in its orbit, supposed circular, it would fall into the sun in a time :

(A) $\frac{1}{8}$ of its period

(B) $\frac{2}{8}$ of its period

(C) $\frac{\sqrt{2}}{8}$ of its period

(D) $\frac{\sqrt{3}}{8}$ of its period

6. A particle describes an ellipse under a force to the focus S. When the particle is at one extremity of the minor axis, its Kinetic energy is doubled, without any change in its direction of motion. The particle proceeds to describe :

(A) Parabola

(B) Hyperbola

(C) Ellipse

(D) Circle

7. 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 w along an axis passing through the centre of mass and perpendicular to the rod. The angular momentum of the system is :

(A) $\frac{mM}{m+M}wr^2$

(B) $\frac{mM}{m-M}wr^2$

(C) $\frac{m+M}{mM}wr^2$

(D) $\frac{m-M}{mM}wr^2$

SEAL

8. A small sphere of radius R in its proper frame is moving with half velocity of light. When photographed by an observer in a laboratory frame it looks like :

(A) Ellipsoid

(B) A hyperboloid

(C) Sphere

(D) A paraboloid

9. The frequency of oscilations of a particle of mass m which is free to move along a line and is attached to a spring whose other end is fixed at a point at a distance ℓ from the line. The frequency of oscillations, where F is force :

(A) $\sqrt{\frac{F}{m\ell}}$

(B) $\sqrt{\frac{m}{F\ell}}$

(C) $\sqrt{\frac{F\ell}{m}}$

(D) $2\sqrt{\frac{F}{m\ell}}$

10. Two identical charges +Q are kept fixed some distance apart. A small particle P with charge q is placed midway between them. If P is given a small displacement Δ, it will undergo simple harmonic motion if :

(A) q is positive and the given displacement is along the line joining the charges

(B) q is positive and the given displacement is perpendicular to the line joining the charges

(C) q is negative and the given displacement is along the line joining the charges

(D) None of the above

11. A positive charge Q is brought near an isolated metal cube :

(A) The cube becomes negatively charged

(B) The cube becomes positively charged

(C) The interior becomes positively charged and the surface becomes negatively charged

(D) The interior remains charge free and the surface gets non uniform charge distribution

12. A sphere of radius 2m is kept in space such that its center is on y axis at (0, a). A charge of 1C is kept at (1, 0). In which of the following cases, the flux through the sphere is not zero ?

(A) a = 2m

(B) a = –2m

(C) a = 1m

(D) a = –3m

13. If we seal a pipe with two metal end caps around a point charge Q, the electric field outside the pipe will be :

(A) Identical to the field of an isolated point charge

(B) Identically zero, because metal shields charge

(C) Non-zero but dependent on where the charge is within the pipe

(D) Non-zero but independent of where the charge is within the pipe

14. If magnetic field $\vec{B} = \nabla \times \vec{A}, \vec{A}$ being the vector potential, then for constant magnetic field we have :

(A) $\vec{A} = \frac{1}{2}(\vec{B} \times \vec{\Delta})$

(B) $\vec{A} = \frac{1}{2}(\vec{r} \times \vec{B})$

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

(D) 0

15. If an electric dipole is rotating about its center with a uniform angular velocity in the anticlockwise direction in a uniform magnetic field which is in the direction of the angular velocity :

(A) Net magnetic forces as well as torque on the dipole is zero

(B) Net magnetic forces as well as torque on the dipole is non zero

(C) Net magnetic force is zero but the net torque on the dipole is non-zero

(D) Net magnetic force on the dipole is not zero but the net torque on the dipole is zero

16. An electric current runs counterclockwise in a rectangular loop around the outside edge of this page, which lies flat on your table. A uniform field is then turned on, directed parallel to the page from top to bottom. The magnetic force on the page will cause :

(A) The left edge to lift up

(B) The right edge to lift up

(C) The top edge to lift up

(D) The bottom edge to lift up

17. 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) $E = \frac{2B}{\sqrt{\mu \epsilon_0 (1+\chi)}}$

18. Four very long straight wires carry equal electric currents in the +z direction. They intersect the xy plane at (x, y) = (–a, 0), (0, a), (a, 0) and (0, –a). The magnetic force exerted on the wire at position (–a, 0) is along :

(A) +y

(B) –y

(C) +x

(D) –x

19. Two long straight thin wires carrying steady currents pass near each other at right angles to each other. As time passes :

(A) They will move away from each other, parallel to their original positions

(B) They will move towards each other parallel to their original positions

(C) They will rotate about the line of the shortest distance between them and tend to be parallel to each other

(D) They will rotate about the line of the shortest distance between them and tend to be anti-parallel to each other

20. The time averaged energy in an electromagnetic wave is :

(A) Overwhelmingly electrical

(B) Slightly more electrical than magnetic

(C) Equally divided between electrical and magnetic

(D) Overwhelmingly magnetic

21. The correct relation between the pressure and Kinetic energy per unit volume of the gas is :

(A) $P = \frac{3}{2}E$

(B) $P = \frac{2}{3}E$

(C) $P = \frac{1}{3}E$

(D) $E = \frac{1}{3}P$

22. Which of the following relations is correct where γ Specific heat ratios, f is the number of degrees of freedom ?

(A) $\gamma = 1 + f$

(B) $\gamma = 1 - f$

(C) $\gamma = 1 + \frac{f}{2}$

(D) $\gamma = 1 + \frac{2}{f}$

23. The relation between Boyle's temperature and critical temperature is :

(A) $2T_B = \frac{8}{27}T_c$

(B) $T_B = \frac{27}{8}T_c$

(C) $T_B = \frac{3}{2}T_c$

(D) $3T_B = \frac{5}{13}T_c$

24. 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) $\frac{W}{Q} = 1$

25. The percentage of lighter gases like hydrogen and helium is very high in the atmosphere of the earth. This can be explained on the basis of :

(A) Kinetic theory of matter

(B) Temperature gradient of the atmosphere

(C) Brownian motion of the gas molecules

(D) Concept of equipartition energy

26. For a thermodynamic system, Helmholtz free energy is a function of :

(A) S, V

(B) V, T

(C) T, P

(D) S, P

27. If ΔS is the change in entropy, ΔV the change in volume of the two phases, then Clausius-Clapeyron equation is :

(A) $\frac{dP}{dT} = \frac{\Delta S}{\Delta V}$

(B) $\frac{dP}{dT} = \frac{1}{\Delta S \Delta V}$

(C) $\frac{dP}{dT} = T\frac{\Delta S}{\Delta V}$

(D) $\frac{dP}{dT} = \frac{\Delta V}{T\Delta S}$

28. The relative number of gas molecules travelling distance s without collisions is (λ is mean free path) :

(A) $\frac{N}{N_0} = e^{-s\lambda}$

(B) $\frac{N}{N_0} = e^{s\lambda}$

(C) $\frac{N}{N_0} = e^{-s\lambda^2}$

(D) $\frac{N}{N_0} = e^{-s^2\lambda}$

29. Five particles are distributed in two phase cells. The number of macrostates are :

(A) 10

(B) 6

(C) 5/2

(D) 32

30. The classical Statistics is valid if the average separation between the particles is much greater than the mean de-Broglie wavelength of the particles. Then which of the following is not correct to satisfy this condition ?

(A) Temperature is large

(B) Gas is dilute

(C) Mass of particles is not too small

(D) Number density is very large

31. If the volume of black body radiation is increased quasistatically and adiabatically by a factor of 8, then the wavelength of the highest intensity λ_m will shift to :

(A) $\frac{1}{2}\lambda_m$

(B) $2\lambda_m$

(C) $2\sqrt{2}\lambda_m$

(D) $8\lambda_m$

32. The microstate of a system at any time is given by specifying the :

(A) Maximum possible information about the system molecules at different time

(B) Minimum possible information about the system molecules at same time

(C) Minimum possible information about the system molecules at different times

(D) Maximum possible information about the system molecules at same time

33. Consider two waves passing through the same string. Principle of superposition for displacement says that the net displacement of a particle on the string is the sum of the displacements produced by the two waves individually. Suppose we state the similiar Principle for the net velocity and the net Kinetic energy of the particle. Such a Principle will be valid for :

(A) both the velocity and the Kinetic energy

(B) the velocity but not for the Kinetic energy

(C) the Kinetic energy but not the velocity

(D) neither the velocity nor the Kinetic energy

34. Two periodic waves of amplitudes A_1 and A_2 pass through a region. If $A_1 > A_2$, the difference in the maximum and minimum resultant amplitude possible is :

(A) $2A_1$

(B) $2A_2$

(C) $A_1 + A_2$

(D) $A_1 - A_2$

35. A sonometer wire of length ℓ vibrates in fundamental mode when excited by a tuning fork of frequency 416Hz. If the length is doubled, keeping other things same, the string will :

(A) vibrate with a frequency of 416 Hz

(B) vibrate with a frequency of 208 Hz

(C) vibrate with a frequency of 832 Hz

(D) stop vibrating

36. A standing wave is produced on a string clamped at one end and free at the other. The length of the string :

(A) must be an integral multiple of $\frac{\lambda}{4}$

(B) must be an integral multiple of $\frac{\lambda}{2}$

(C) must be an integral multiple of λ

(D) may be an integral multiple of $\frac{\lambda}{2}$

37. Monochromatic light of wavelength 600 nm is used in a Young's double slit experiment. One of the slits is covered by a transparent sheet of thickness 1.8×10^{-5} m made up of material of refractive index 1.6. The number of fringes that shift due to introduction of sheet is :

(A) 6

(B) 12

(C) 18

(D) 20

38. Two coherent point sources S_1 and S_2 vibrating in phase emit light of wavelength λ. The separation between the sources is 2λ. Consider a line passing through S_2 and perpendicular to the line S_1S_2. The smallest distance from S_2 where a minimum of intensity occurs :

(A) $\frac{\lambda}{12}$

(B) $\frac{7\lambda}{12}$

(C) $\frac{\lambda}{2}$

(D) $\frac{2\lambda}{7}$

39. At the first minimum adjacent to the central maximum of a single slit diffraction pattern the phase difference between the Huygens wavelet from the top of the slit and the wavelet from the midpoint of the slit is :

(A) $\frac{\pi}{2}$ radians

(B) $\frac{\pi}{8}$ radians

(C) $\frac{\pi}{4}$ radians

(D) π radians

40. Light is reflecting off a wedge shaped thin piece of glass producing bright and dark fringes. If a certain location has a bright fringe, a nearby point will have dark fringe if the thickness of the glass increases by :

(A) $\frac{1}{8}$ of a wavelength of the light in glass

(B) $\frac{1}{4}$ of a wavelength of the light in glass

(C) $\frac{1}{2}$ of a wavelength of the light in glass

(D) 1 wavelength of light in glass

41. In Compton effect the change in wavelength of light depends on :

(A) Target material

(B) Initial wavelength of light

(C) Scattering angle

(D) None of the above

42. The electron in a ground state hydrogen atom is in circumference equal to :

(A) One de-Broglie wavelength

(B) Two de-Broglie wavelength

(C) 10 de-Broglie wavelength

(D) Twelve and half de-Broglie wavelength

43. The lowest energy possible for a particle in a one dimensional potential box is 2eV. The next highest energy of the particle can have :

(A) 4 eV

(B) 8 eV

(C) 16 eV

(D) 32 eV

44. At what value of Kinetic energy is the de-Broglie wavelength of an electron equal to Compton wavelength ?

(A) $(\sqrt{2}+1)m_0c^2$

(B) $\frac{1}{\sqrt{2}}m_0c^2$

(C) m_0c^2

(D) $(\sqrt{2}-1)m_0c^2$

45. Normal Zeeman effect :

(A) is observed with atoms having odd number of electrons

(B) is observed with only atoms with even number of electrons

(C) confirms the theory of space quantization

(D) disproves the theory of space quantization

46. If the orbital angular momentum of an electron is $\sqrt{20}\hbar$. Its orbital number quantum number must be :

(A) 4

(B) –4

(C) 20

(D) –20

47. Decay of μ-meson supports the concept of :

(A) Relativity of mass

(B) Relativity of energy

(C) Time dilation

(D) Length contraction

48. A free neutron decays into a proton with the emission of an electron and a third particle to conserve angular momentum. The third particle is :

(A) Neutrino

(B) Gamma-ray

(C) Anti-Neutrino

(D) Neutron

49. The energy of a photon of sodium light ($\lambda = 589$ nm) equals the band gap of semiconducting material. The minimum energy required to create electron-hole pair is approximately :

(A) 1MeV

(B) 1eV

(C) 2 eV

(D) 2MeV

50. A crystallographic plane has intercept 1 along a, 2 along b, 3 along c. A parrallel plane to this plane will have Miller indices :

(A) (632)

(B) (246)

(C) (123)

(D) (321)

51. If there are two atoms in the primitive basis then in the phonon dispersion will have :

(A) one acoustic and two optical branches

(B) one acoustic and one optical branches

(C) two acoustic and two optical branches

(D) three acoustic and three optical branches

52. Braggs angles for the first and second order reflections by a crystal are respectively θ_1 and θ_2.

Then $\frac{\sin\theta_1}{\sin\theta_2}$ is :

(A) 1

(B) 2

(C) 0.5

(D) 0.25

53. Diffusion current in a pn-junction is greater than the drift current in magnitude :

(A) if the junction is forward biased

(B) if the junction is reverse biased

(C) if the junction is unbiased

(D) in no case

54. In a transistor :

(A) the emitter has least concentration of impurity

(B) the collector has the least concentration of impurity

(C) the base has the least concentration of impurity

(D) all the three regions have equal concentration of impurity

55. A semiconducting device is connected in a series circuit with a battery and a resistance. A current is found to pass through the circuit. If the polarity of the battery is reversed, the current drops to almost zero. The device may be :

(A) an intrinsic semiconductor

(B) a p-type semiconductor

(C) an n-type semiconductor

(D) a p-n junction

56. In a semiconductor :
(A) there are only free electrons at 0K
(B) there are no free electrons at any temperature
(C) there number of free electrons increases with temperature
(D) none of the above

57. The positive gate operation of an n-channel MOSFET is known as :
(A) Depletion mode
(B) Enhancement mode
(C) Normal
(D) Neither Depletion nor Enhancement mode

58. MOSFET is also known as :
(A) Uni-Junction transistor
(B) Complementary metal-oxide-semiconductor
(C) Insulated gate field-effect transistors
(D) Bipolar junction transistor

59. FET is a device which has :
(A) low input impedance and is current controlled
(B) low input impedance and is voltage controlled
(C) high input impedance and is current controlled
(D) high input impedance and is voltage controlled

60. The transistors are :
(A) low voltage and low current devices
(B) high voltage and high current devices
(C) low voltage and high current devices
(D) only low current devices

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 $\lim_{x \to a} V(x) \to \infty$?

(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 ?

(A) An atom is always electrically neutral

(B) Isotopes are present

(C) Some atoms are radioactive in nature

(D) All of the above

8. Which of the following is a fundamental particle ?

(A) Proton

(B) Electron

(C) Fermion

(D) Boson

9. The primitive lattice vectors of a BCC lattice are :

(A) [0, 0, 0], [0, 1, 0], $\left[\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right]$

(B) [0, 1, 0], [0, 1, 0], $\left[\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right]$

(C) [1, 0, 1], [0, 1, 0], $\left[\frac{1}{2}, \frac{1}{2}, \frac{1}{2}\right]$

(D) [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 :

(A) Proportional to T^4

(B) Proportional to T^3

(C) Proportional to T^{-3}

(D) 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 :

(A) M

(B) M^2

(C) M/2

(D) M – 1

12. The quantum effects in a copper electrical wire are not dominant because of :

(A) High lattice vibrations

(B) Copper is a conductor

(C) High Fermi energy

(D) Low heat capacity

13. The ratio of energy gap of silicon to that of diamond is :

(A) $\frac{1}{100}$

(B) $\frac{2}{25}$

(C) $\frac{1}{6}$

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

14. The electrical conductivity of a metal with electron relaxation time τ is :

(A) Independent of τ

(B) Inversly proportional to τ

(C) Directly proportional to τ

(D) 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) $\beta = \dfrac{1-\alpha}{1+\alpha}$

(B) $\beta = \dfrac{\alpha^2}{1-\alpha^2}$

(C) $\beta = \dfrac{\alpha}{1-\alpha}$

(D) $\beta = \dfrac{\alpha^2}{1+\alpha^2}$

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) $\upsilon = \sqrt{2D\mu g}$

(B) $\upsilon = \sqrt{4D\mu g}$

(C) $\upsilon = \sqrt{D\mu g}$

(D) $\upsilon = \sqrt{D\mu}$

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) $\vec{A} = \frac{1}{2}(\vec{B} \times \vec{\Delta})$

(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 $\vec{E}(x,y,z,t) = (\vec{P}\hat{i} + \vec{Q}\hat{j})e^{-i(kz-wt)}$ 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 $\gamma = \frac{c_p}{c_\upsilon}$ is :

(A) $C_\upsilon = \frac{R}{1-\gamma}$

(B) $C_\upsilon = \frac{R}{\gamma}$

(C) $C_\upsilon = \frac{R}{1+\gamma}$

(D) $C_\upsilon = \frac{1-R}{1-\gamma}$

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 A

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, ..., 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-Einstien Distribution

(C) Maxwell-Boltzmann Distribution

(D) All of the above

53. The amplitude of the following simple harmonic motion $x(t) = A\cos(wt)\,\hat{i} + \sqrt{2}A\cos\left(wt + \frac{\pi}{4}\right)\hat{j}$:

(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 w_0 is :

(A) $\left(\frac{w_0}{4\alpha}\right)^2$

(B) $\left(\frac{w_0}{4\alpha}\right)$

(C) $\left(\frac{w_0}{4\alpha}\right)^{\frac{3}{4}}$

(D) $\left(\frac{w_0}{4\alpha}\right)^{\frac{1}{4}}$

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 Focault 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 $F_{ext} = F_0 \cos \omega t$ 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:

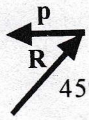
(A) F = – grad V

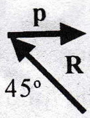
(B) F = – div V

(C) F = – curl V

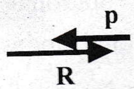
(D) F = – div V^2

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

1. 

2. 

3. 

4. 

(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 0.6 C w.r.t. ground along the direction of X. The dimensions in the system S' are (i and j are unit vectors)

(A) (4 i + 6 j)

(B) (6 i + 4 j)

(C) (4 i + 9 j)

(D) (5 i + 4 j)

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 (μ=0.6421). It implies that the material is (Take $\mu_0 = 4\pi \times 10^{-7}$) :

(A) Paramagnetic

(B) Diamagnetic

(C) Ferromagnetic

(D) Anti-ferromagnetic

16. Line integral of B around a path enclosing a long wire carrying current 20mA is (take $\mu_0 = 4\pi \times 10^{-7}$):

(A) 8.48×10^{-9} Wbm-2

(B) 5.72×10^{-4} Wbm-2

(C) 2.51×10^{-8} Wbm-2

(D) 7.76×10^{-6} Wbm-2

17. The statement equivalent to $\int_C B.dl = \mu_0 I$ is:

(A) $\nabla.B = \mu_0 I$

(B) $\nabla \times B = \mu_0 E$

(C) $\nabla \times B = \mu_0 J$

(D) $\nabla.B = 0$

18. Which of the following statements is false?

(A) In an electromagnetic field, the electric and magnetic field energy densities are equal

(B) In an electromagnetic wave, the electric and magnetic field vectors E and B are equal in magnitude

(C) In an electromagnetic wave, electric and magnetic fields are in phase

(D) 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):

(A) 0.0812 and 0.9188

(B) 0.8120 and 0.1880

(C) 0.9925 and 0.0075

(D) 0.0278 and 0.9722

20. The units of Poynting vector $S = (E \times B)/\mu_0$ are:

(A) $JS^{-2}m^{-2}$

(B) JSm^{-2}

(C) JSm^{-1}

(D) $JS^{-1}m^{-2}$

21. A diatomic gas molecule has 6 degrees of freedom. For these 6 degrees of freedom, the following break-up is correct

(A) 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.

(B) 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.

(C) 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.

(D) 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:

(A) both 'a' and 'b' are large

(B) both 'a' and 'b' are small

(C) 'a' is small and 'b' is large

(D) 'a' is large and 'b' is small

23. The entropy of a four coin system, if all the four coins are heads up, is

(A) 0

(B) 1.5 J/K

(C) 3.7 J/K

(D) 9.2 J/K

24. The ratio of the specific heats γ (=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:

i. The second law of thermodynamics implies that all natural processes lead to an increase in entropy.

ii. The third law of thermodynamics implies that a body cannot be brought to absolute zero temperature by a finite sequence of events.

iii. 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.

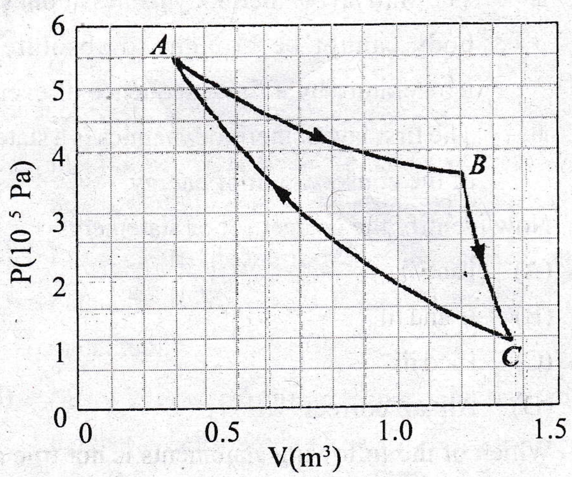
(B) The wave functions of particles obeying Bose Einstein statistics are symmetric to interchange of particles.

(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 $x = A\sin(wt) + B\cos(wt)$ 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.

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

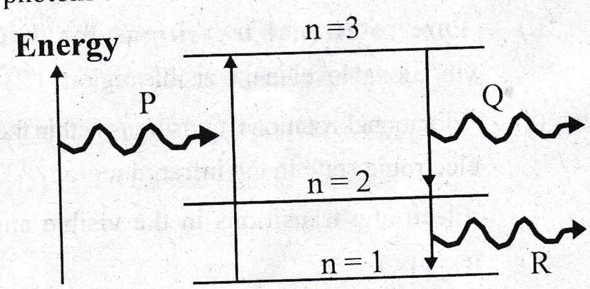
(A) the number of photons inside the blackbody was conserved

(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 <p> 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 $n \to p + \pi^-$ 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:

(A) Simple Cubic

(B) Base centered Cubic

(C) Body centered cubic

(D) Face centered cubic

54. The Miller indices of a plane having intercepts 4a, 2b, 3c on the a, b, c axes respectively are

(A) (324)

(B) (342)

(C) (364)

(D) (423)

55. The form of the potential in the Kronig-Penney model is

(A) periodic square wave

(B) simple Coulomb potential

(C) screened Coulomb potential

(D) Yukawa potential

56. The probability that an electron in a metal occupies the Fermi-level, at any temperature (> 0 K) is

(A) 0

(B) 0.25

(C) 0.5

(D) 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:

(A) normal to current and parallel to magnetic field

(B) normal to magnetic field but parallel to current

(C) parallel to both current and magnetic field

(D) normal to both current and magnetic field

58. For a JFET, when VDS is increased beyond the pinch off voltage, the drain current

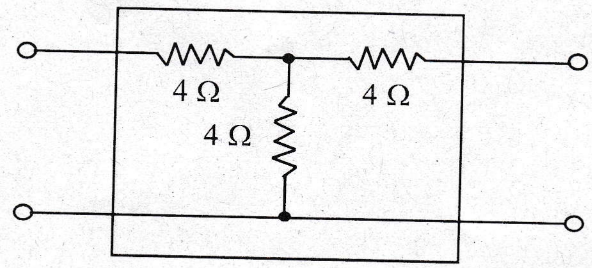
(A) Increases exponentially

(B) Decreases exponentially

(C) Remains constant

(D) 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



(A) 10 Ω, 4, – 4

(B) 8 Ω, 2, – 2

(C) 4 Ω, – 4, 2

(D) 6 Ω, – 0.5, 0.5

60. MOSFET can be used as

(A) Voltage controlled capacitor

(B) Current controlled capacitor

(C) Voltage controlled inductor

(D) Current controlled inductor

Sr. No. 0037

ENTRANCE TEST-2016

FACULTY OF PHYSICAL AND MATERIAL SCIENCE

M.Sc. PHYSICS

Total Questions : 60

Time Allowed : 70 Minutes

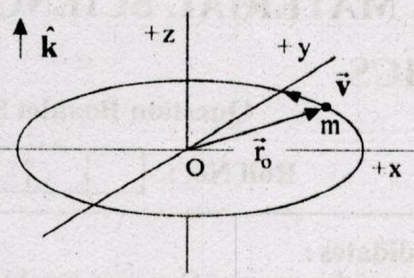
Question Booklet Series **A**

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.

1. A particle of mass m moves in a circle of radius r at an angular speed ω about the z-axis in a plane parallel to the x-y plane passing through the origin O (Figure below). The magnitude and direction of the angular momentum $\vec{L_o}$ relative to the origin is :



(A) $mr^2\omega\hat{i}$ (B) $mr^2\omega\hat{j}$

(C) $mr\omega^2\hat{j}$ (D) $mr^2\omega\hat{k}$

2. Which of the following statements are true about the motion under a central force ?

(i) The angular momentum (of the particle) is a constant of motion

(ii) Central forces are conservative in nature

(iii) The motion is planar (always confined to a fixed plane)

(iv) The areal velocity of the radius vector (joining the particle with the centre) is a constant

(A) (i), (ii) and (iii) (B) (ii), (iii) and (iv)

(C) (iv), (i) and (ii) (D) All are true

3. The mutual potential energy V of two particles depends on their mutual distance r as;

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

If the particles are in static equilibrium, then the separation is :

(A) $\frac{2b^2}{a}$ (B) $\frac{2a^2}{b}$

(C) $\frac{2a}{b}$ (D) $\frac{b^2}{2a}$

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 ?

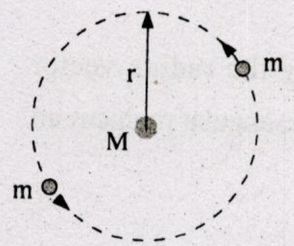
(A) $\frac{A}{\sqrt{2}}$

(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 starts 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) Amphere'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 $(n+1)^{th}$ 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 ψ(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 $<p>$ for the wavefunction $\psi(x)$, then the expectation value of momentum for the wavefunction $e^{2\pi ikx/h}\,\psi(x)$ is :

(A) $<p> - k<x>^2$ (B) $<p> + k<x>$

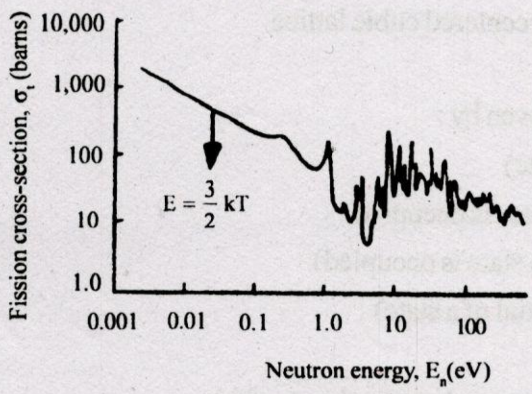
(C) $<p>$ (D) $<p> + k$

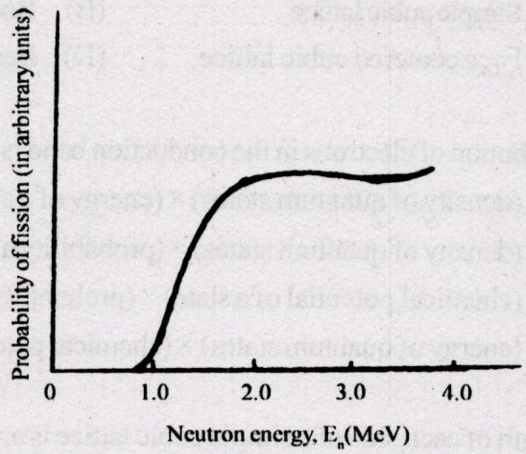
49. The Kronig Penney model that describes the general characteristics of the quantum behaviour of electrons in solids assumes :

(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 :

$n \rightarrow p + \pi^-$

(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) × (energy of a state)

(B) (density of quantum states) × (probability a state is occupied)

(C) (chemical potential of a state) × (probability a state is occupied)

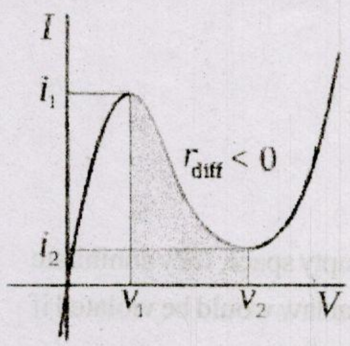
(D) (energy of quantum states) × (chemical potential of a state)

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 transitor (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 RC = 500 Ω and the input impedance is 1 kΩ. Calculate the overall gain when two such stages are cascaded through R-C coupling :

(A) 3442

(B) 120

(C) 2397

(D) 3593

ROUGH WORK

M. Sc. Physics/A

1. The surface area element in spherical polar coordinate system can be written as :
   (A) $r^2 sin\theta\, dr\, d\theta\, d\varphi$
   (B) $r^2 sin^2\theta\, dr\, d\theta\, d\varphi$
   (C) $r^2 sin\theta\, d\theta\, d\varphi$
   (D) $r\, sin\theta\, dr\, d\theta\, d\varphi$

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 × Time period of Earth
   (B) 10 × Time period of Earth
   (C) 8 × Time period of Earth
   (D) 12 × 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) 43.6×10^{-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) $\vec{\nabla} \cdot \vec{E} = \frac{\rho_F}{\epsilon_o}$

(B) $\vec{\nabla} \cdot \vec{E} = \frac{\rho_F + \rho_B}{\epsilon}$

(C) $\vec{\nabla} \cdot \vec{E} = \frac{\rho_B}{\epsilon_o}$

(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_o 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) $\frac{1}{2} \epsilon_o E^2$

(B) $\frac{1}{2} \epsilon_o \mu_o B^2$

(C) $\frac{1}{2} c \epsilon_o E^2$

(D) $\frac{1}{2} \mu_o B^2$

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}, $\overline{V}$ 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) $V_{RMS} < \overline{V} < V_p$ (B) $\overline{V} < V_{RMS} < V_p$

(C) $V_p < \overline{V} < V_{RMS}$ (D) $V_{RMS} < V_p < \overline{V}$

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 revere biased properly doped crystal diode having a sharp break-down voltage

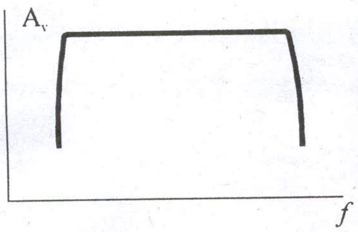
(B) The breakdown voltage, called the *Zener voltage*, depends upon the amount of doping

(C) If a Zener diode is heavily doped the Zener voltage is low

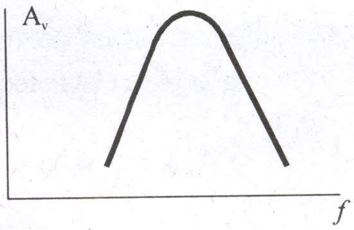
(D) When a Zener diode is operated in the forward bias region, the voltage across it remains practically constant for a large change in the current

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

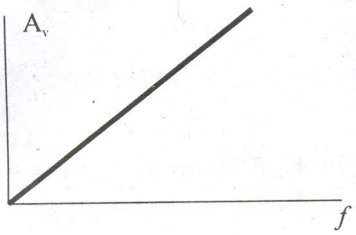
(A)



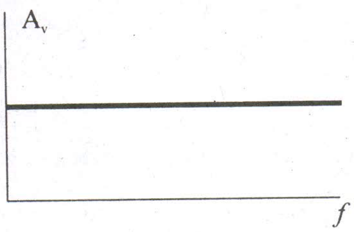
(B)



(C)



(D)



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.

1. 110 J of heat is added to a gaseous system whose internal energy is 40 J then the amount of external work done is :
   (A) 150 J (B) 70 J
   (C) 110 J (D) 40 J

2. If the temperature of the sun is doubled the rate of energy received on earth will be increased by a factor of :
   (A) 2 (B) 4
   (C) 8 (D) 16

3. If one gram of steam is mixed with one gram of ice then resultant temperature of the mixture is :
   (A) 100° C (B) 230° C
   (C) 270° C (D) 50° C

4. An ideal gas at 27° C is compressed adiabatically to $\frac{8}{27}$ of its original volume the rise in temperature is (take $\gamma = \frac{5}{3}$) :
   (A) 275 K (B) 475 K
   (C) 375 K (D) 175 K

5. Heat is flowing through two cylindrical rods of the same material. The diameters of the rods are in the ratio 1 : 2 and the lengths in the ratio 2 : 1 if the temp difference between the ends is same, then the ratio of the rate of the flow of heat through them will be :
   (A) 2 : 1 (B) 8 : 1
   (C) 1 : 1 (D) 1 : 8

6. A mass 'm' is suspended from the two coupled springs connected in series. The force constant for springs are K_1 and K_2. The time period of the suspended mass will be :
   (A) $T = 2\pi\sqrt{\frac{m}{K_1 - K_2}}$ (B) $T = 2\pi\sqrt{\frac{mK_1 K_2}{K_1 + K_2}}$
   (C) $T = 2\pi\sqrt{\frac{m}{K_1 + K_2}}$ (D) $T = 2\pi\sqrt{\frac{m(K_1 + K_2)}{K_1 K_2}}$

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 amplitute 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 $y_1 = 4sin(500\pi t)$ and $y_2 = 2sin(506\pi t)$, 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 $y(x, t) = 8.0\, Sin(0.5\,\pi x - 4xt - \frac{\pi}{4})$ where x is in meters and t is in seconds. The speed of the wave is :

(A) $8\ ms^{-1}$
(B) $4\ \pi ms^{-1}$
(C) $0.5\ \pi ms^{-1}$
(D) $\frac{\pi}{4} ms^{-1}$

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 = 9.1×10^{-31} 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) 1.602×10^{-17} J (D) 1.6×10^{4} 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 6.0×10^{14} Hz is provided by a laser. The power emitted on the average is $2 \times 10^{-3} W$. 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

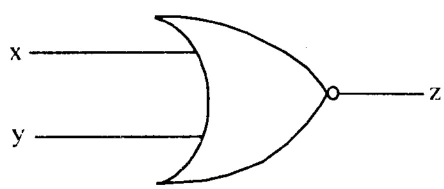
28. The truth table given here is valid for which of the following gates ?

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 then 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 dopped 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 transitional 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
   (a) System attached to the earth
   (b) System referred to the fixed stars
   (c) System that is acted upon by zero net force
   (d) Uniformly moving aircraft

2. Electromagnetic Maxwell's equations are invariant under :
   (a) Galilean transformation
   (b) Lorentz transformation
   (c) Both Galilean and Lorentz transformation
   (d) None of (a) to (c)

3. What is the correct relativistic transformation for the y-component of velocity (relative velocity along x-direction) ?

   (a) $V_y' = \frac{V_y \sqrt{(1-v^2/c^2)}}{(1-vV_x/c^2)}$ (b) $V_y' = \frac{V_y \sqrt{(1-v^2/c^2)}}{(1-vV_y/c^2)}$

   (c) $V_y' = \frac{V_y - v}{(1-vV_x/c^2)}$ (d) $V_y' = V_y$

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 ?
   (a) Twins clocks will show same time and this time will be less than the elapsed time on the earth
   (b) Twins clocks will show same time and this time will be greater than the elapsed time on the earth
   (c) Twins clocks will show different times and one twin clock will show same time as on the earth based clock
   (d) 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 ?
   (a) On the North Pole (b) On the South Pole
   (c) In Pacific Ocean (d) 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 ?

(a) When two sine waves are of equal frequency and in-phase, a diagonal line to the right is produced

(b) When two sine waves are of equal frequency and 180° out of phase, a diagonal line to the left is produced

(c) When two sine waves are of equal frequency and 90° out of phase, a circle is produced

(d) 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 ?

(a) In the damped case, the steady state behavior depend on the initial conditions

(b) In the undamped case, beats occur when the forcing frequency is close to (but not equal to) the natural frequency of the oscillator

(c) The second order linear harmonic oscillator (damped or undamped) with sinusoidal forcing can be solved by using the method of undetermined coefficients

(d) 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 :

(a) Zero (b) $\vec{A}$

(c) $\vec{B}$ (d) $\vec{B}/2$

15. If $\vec{B} = \nabla \times \vec{A}$, the value of the surface integral $\int\int \vec{B} . d\sigma$ (integral is over a closed surface) is equal to :

(a) Infinity (b) Zero

(c) $\vec{A}$ (d) None of (a) to (c)

16. Which of the following statement is correct in the multipole expansion of the electric field ?

(a) Dipole moment changes on shifting the origin if the net charge is zero

(b) Point charge at the origin has both monopole and dipole moment

(c) Point charge away from the origin has only monopole moment

(d) 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 exit
(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) $E\,B = constant$
(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 $V \to \infty$
(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 $0^{o}C$ is melted and converted to water at $0^{o}C$. 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 $\left(\vec{E}\right)$ is equal to :

(a) $\vec{E}$ (b) Zero

(c) E (d) $E\,\vec{E}$

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) Liner shape for all velocities

30. The pressure amplitude of a sound wave depends on :
   (a) Displacement amplitude
   (b) Wavelength of the sound wave
   (c) Bulk modulus of the material through which sound is propagating
   (d) All of (a) to (c)

31. In which of the following wave, polarization phenomenon is not possible ?
   (a) Longitudinal wave
   (b) Transverse wave
   (c) X-rays
   (d) Gamma-rays

32. The lens aberration is not due to :
   (a) Nonparaxial nature of the rays from the object
   (b) Variation of the Index of the refraction with wavelength
   (c) Faulty construction of the lens
   (d) Finite size of the lens

33. What is the advantage of the diffraction grating in spectrometry ?
   (a) Velocity of the light can be measured
   (b) Wavelength of the light can be computed
   (c) Refractive index of the medium can be computed
   (d) All of (a) to (c)

34. The output of a laser has a pulse width of 30×10^{-3} *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 ?
   (a) 10^{16}
   (b) 10^{10}
   (c) 10^{2}
   (d) 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 :
   (a) $500 \times 10^{-6}\ m$
   (b) $500 \times 10^{-3}\ m$
   (c) $500 \times 10^{-0}\ m$
   (d) $500 \times 10^{-9}\ m$

36. Which are the two fundamental principles of quantum mechanics ?
   (a) Lorentz invariance and Bohr quantization
   (b) Energy and angular-momentum quantization
   (c) Linear Superposition and Uncertainty
   (d) 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 Brogli 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 eigen-value 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 :
   (a) 100 times smaller than that of β particle
   (b) 100 times greater than that of β particle
   (c) Equal to that of β particle
   (d) 1000 times less than that of β particle

50. The major difference between electron and positron spectra in β-decay is :
   (a) Many low energy electrons and very few low energy positrons
   (b) Many high energy electrons and very few high energy positrons
   (c) Electron spectrum is peaked and positron spectrum is not peaked
   (d) 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 :

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

   (c) $\frac{1}{4r^2}$ (d) None of (a) to (c)

52. In ferromagnetism :
   (a) Number of electrons with opposite spin are equal
   (b) Number of electrons with opposite spin are zero
   (c) There is no magnetic moment
   (d) Number of electrons with opposite spin are unequal

53. The Free electron model of metals fails to explain the following property :
   (a) Distinction between metals, semimetals and conductors
   (b) Occurrence of positive values of the Hall coefficient
   (c) Relation of conduction electrons in the metal to the valence electrons of free atoms
   (d) All of (a) to (c)

54. Which of the following statement is incorrect ?
   (a) Alkaline earth elements have two valence electrons per primitive cell, but the bands overlap in energy and, therefore, are metals
   (b) Alkaline earth elements have two valence electrons per primitive cell and are insulators
   (c) Alkali metals have one valence electron per primitive cell, so that they have to be metals
   (d) 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 Ω and 800 Ω are connected in series with 6 *volt* battery. To measure the current in the circuit, an ammeter of 10 Ω resistance is used. The reading in the ammeter is :

(a) 2.6 mA

(b) 1.92 mA

(c) 5.96 mA

(d) 4.96 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

1. 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
   - (a) $2\upsilon/\sqrt{3}$
   - (b) $\sqrt{2}\upsilon/3$
   - (c) $\sqrt{2/3}\,\upsilon$
   - (d) $\sqrt{3/2}\,\upsilon$

2. The mass of a hypothetical planet is 1/100 that of Earth and its radius is 1/4 that of Earth. If a person weigh 75 N on Earth, what would he weigh on this planet ?
   - (a) 75 N
   - (b) 24 N
   - (c) 12 N
   - (d) 6 N

3. The flow of a liquid is said to be turbulent if its Reynold number is more than :
   - (a) 3
   - (b) 30
   - (c) 300
   - (d) 3000

4. Bernoulli's equation applies to :
   - (a) An incompressible fluid, not neccesarily viscous
   - (b) A static fluid only
   - (c) An incompressible, nonviscous, nonturbulent fluid
   - (d) An incompressible, viscous, and nonturbulent fluid

5. Which of the following statements is not completely correct about stationary waves ?
   - (a) Stationary waves are formed by the superposition of two wave trains of the same frequency and amplitude travelling in opposite directions.
   - (b) Stationary waves can be transverse or longitudinal
   - (c) In longitudinal stationary waves, antinodes are the points where there is no pressure or density change
   - (d) Stationary waves do not advance but there is net transfer of energy.

6. 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 :
   - (a) $T_A = T_B$ and $E_A > E_B$
   - (b) $T_A < T_B$ and $E_A > E_B$
   - (c) $T_A > T_B$ and $E_A < E_B$
   - (d) $T_A = T_B$ and $E_A < E_B$

7. An inertial frame is a frame in which :

(a) there are no forces

(b) there are no accelerations without applied forces

(c) relativistic mechanics holds good but the Newtonian mechanics does not

(d) 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 :

(a) 3.3 Kg (b) 4.4 Kg

(c) 2.5 Kg (d) 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 ?

(a) 0.4 C (b) 0.6 C

(c) 0.8 C (d) 0.9 C

10. Three identical particles travel with the velocities indicated in the following options. Which has the greatest kinetic energy ?

(a) $\upsilon = 4i + 3j$ (b) $\upsilon = -4i + 3j$

(c) $\upsilon = 5i$ (d) they are all the same

11. The value of a for which the vector $xi + 2yj + az\,k$ is solenoidal is :

(a) 1 (b) 3

(c) -1 (d) None of the above

12. Curl of the curl of a vector V [i.e. $\nabla \times (\nabla \times V)$] equals :

(a) $\nabla (\nabla.V) - \nabla^2 V$ (b) $\nabla (\nabla \cdot V) + \nabla^2 V$

(c) $\nabla^2 V - \nabla(\nabla.V)$ (d) 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 doubed and the distance separating the particles is also doubled, the force acting on each of the particles has the magnitude :

(a) F (b) 2F

(c) F/2 (d) 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 :

(a) The capacitance falls to half of its initial value and the charge remains the same

(b) The charge doubles and the capacitance remains the same

(c) The capacitance and the charge both fall to half of their initial value

(d) 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 :

(a) $Z=\sqrt{R^2+\left(L\omega+\frac{1}{C\omega}\right)^2}$ (b) $Z=\sqrt{R^2-\left(L\omega+\frac{1}{C\omega}\right)^2}$

(c) $Z=\sqrt{R^2+\left(L\omega-\frac{1}{C\omega}\right)^2}$ (d) $Z=\sqrt{R^2+(L\omega)^2+(C\omega)^2}$

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 ?

(a) T/16 (b) T/4

(c) T/2 (d) 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 :

(a) mv/qB (b) qB/mv

(c) qm/Bv (d) 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 :

(a) Faraday's laws (b) Lenz's law

(c) Guass's law (d) Amphere's law

19. The speed of propagation of an electromagnetic wave in free space of permeability μ_0 and permittivity ϵ_0 is :

(a) $1/\sqrt{\mu_0 \epsilon_0}$ (b) $\sqrt{\mu_0 \epsilon_0}$

(c) $\sqrt{\mu_0/\epsilon_0}$ (d) $\sqrt{\epsilon_0/\mu_0}$

20. For an Ideal gas undergoing an adiabatic process, the pressure P, the Volume V and the ratio of the specific heats $\gamma = Cp/Cv$ are related as :

(a) $PV/\gamma = Constant$
(b) $PV^{\gamma} = Constant$
(c) $VP^{\gamma} = Constant$
(d) $(VP)^{\gamma} = Constant$

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 *Wall's* constants, and R is the molar gas constant. The correct form of the van der *Wall's* equation of state is :

(a) $\left(P - \frac{a}{V_m}\right)\left(V^2_m + b\right) = RT$
(b) $\left[P - \frac{a}{V_m}\right]\left(V^2 m - b\right) = RT$
(c) $\left[P + \frac{a}{V_m}\right]\left(V^2_m - b\right) = RT$
(d) $\left[P + \frac{a}{V^2_m}\right]\left(V_m - b\right) = RT$

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 :

i. Heat never flows spontaneously from a colder body to a hotter body

ii. No engine can have 100% efficiency

iii. 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 :

(a) i. and ii. only (b) i. and iii. only

(c) ii. and iii. only (d) 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 ?

(a) 1 and 2 (b) 2 and 2

(c) 1 and 100 (d) 2 and 100

28. If the temperature of an ideal gas is doubled while holding the pressure constant, the rms speed of the molecule :

(a) is also doubled

(b) becomes $\sqrt{2}$ times the original speed

(c) becomes 4 times the original speed

(d) becomes 8 times the original speed

29. Of the following properties of a wave, the one that is independent of the others is its :

(a) frequency (b) wavelength

(c) speed (d) amplitude

30. Humans with excellent hearing can hear in the frequency range :

(a) 0 Hz – 20 KHz (b) 20 Hz – 20 KHz

(c) 20 KHz – 20 MHz (d) 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 :

(a) $m_1 + m_2$ (b) $m_1 - m_2$

(c) $m_1 m_2$ (d) m_1 / m_2

32. A curved mirror surface can have :

(a) both chromatic and spherical abberations

(b) chromatic abberation but not spherical abberations

(c) spherical abberation but not chromatic abberation

(d) neither chromatic nor spherical abberations

33. Two coherent, monochromatic light waves, each of intensity I, are incident on a point. The total intensity at that point is :

(a) 0

(b) I

(c) 4I

(d) 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 adjuscent bright fringes is :

(a) 1 cm

(b) 0.50 cm

(c) 0.10 cm

(d) 0.01 cm

35. A LASER produces :

(a) a parallel, coherent and monochromatic beam of light

(b) a parallel, non–coherent and monochromatic beam of light

(c) a parallel, coherent but not neccessarily monochromatic beam of light

(d) 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 :

(a) $\theta = \frac{1.22D}{\lambda}$

(b) $\theta = \frac{D}{1.22\lambda}$

(c) $\theta = \frac{\lambda}{1.22D}$

(d) $\theta = \frac{1.22\lambda}{D}$

37. A light ray inside a glass prism is incident at Brewester's angle on the surface of the prism with air outside. Choose the correct statement from the following :

(a) There is no transmitted ray; the reflected ray is plane polarised

(b) There is no reflected ray; the transmitted ray is plane polarised

(c) Transmitted ray is partially polarized; the reflected ray is plane polarised

(d) 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 ?

(a) momentum

(b) momentum and kinetic energy

(c) speed and kinetic energy

(d) momentum and speed

39. A paritcle is trapped in a 1–D infinite square potential well with perfectly rigid walls. If E_0 is the energy of the partitcle 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 then its energy without spin–orbit coupling, by the term (μ_B is the Bohr Magneton)

(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. Homomorphic 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 :

(a) Z reduced by 4 units, A remains unchanged
(b) A reduced by 4 units, Z remains unchanged
(c) A reduced by 4 units, Z reduced by 2 units
(d) A reduced by 4 units, Z increased by 2 units

48. Only one particle among the following has an integral spin. It is :

(a) Proton (b) Neutron
(c) Electron (d) Photon

49. For a Tetragonal lattice system, the restrictions on the conventional Cell Axes and Angles are :

(a) $a \neq b \neq c, \alpha = \beta = \gamma = 90^0$ (b) $a = b = c, \alpha \neq \beta \neq \gamma$
(c) $a = b \neq c, \alpha \neq \beta \neq \gamma$ (d) $a = b \neq c, \alpha = \beta = \gamma = 90^0$

50. The reciprocal lattice to a simple cubic lattice is a :

(a) Simple cubic lattice (b) *bcc* lattice
(c) *fcc* lattice (d) *gcc* lattice

51. The magnetic susceptibility of diamagnetic, paramagnetic and ferromagnetic substances respectively is

(a) positive but small, positive and large, negative
(b) negative, positive but small, positive and large
(c) negative, positive and large, positive but small
(d) 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

(a) T (b) T^2
(c) T^3 (d) T^4

53. The forbidden energy gap in a solid is of the order of 1eV. The solid is most likely :

(a) An insulator at absolute zero
(b) A semiconductor at room temperature
(c) A conductor at low temperature
(d) 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* amplifer,

(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 :

(a) q/ϵ_0

(b) zero

(c) $2q/\epsilon_0$

(d) $8\pi r^2 q/\epsilon_0$

12. How does the electric field strength vary when we enter a uniformly charged spherical cloud ?

(a) decreases inversely as the square of the distance from the surface

(b) decreases directly as the square of the distance from the surface

(c) decreases directly as the square of the distance from the centre

(d) decerases 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 :

(a) V

(b) KV

(c) $(1 + K)V$

(d) $V/(1 + K)$

14. Which of the following statements is *correct* when comparing electric field $\left(\vec{E}\right)$ and electric displacement $\left(\vec{D}\right)$?

(a) both $\vec{E}$ and $\vec{D}$ satisfy Coulomb's law

(b) $\vec{E}$ satisfies Coulomb's law and not $\vec{D}$

(c) $\vec{E}$ satisfies Gauss law and not $\vec{D}$

(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 :

(a) 2R

(b) R

(c) R/2

(d) 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 :

(a) x-direction

(b) y-direction

(c) z-direction

(d) 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 :

(a) E, B and v are mutually perpendicular and $v = E/B$

(b) E is perpendicular to B

(c) E is parallel to v and perpendicular to B

(d) E and B both are parallel to v

18. Which of the following statements is *correct* ?

(a) both electric and magnetic dipole moments depend on the choice of the origin

(b) electric dipole is always independent of the choice of the origin

(c) electric dipole is independent of the choice of the origin only when total charge vanishes

(d) magnetic dipole depends on the choice of the origin

19. What is the origin of Maxwell's equations ?

(a) classical mechanics

(b) quantum mechanics

(c) theory of relativity

(d) 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 :

(a) $\nabla . \vec{E} = 0$

(b) $\nabla . \vec{E} = -\partial \vec{B} / \partial t$

(c) $\nabla . \vec{B} = 0$

(d) 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 $v_x\left(\overline{v_x^2}\right)$ 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 lense and eye lense 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 Å. If we use monochromatic light of wavelength 6000 Å, 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 :

(a) zero

(b) infinite

(c) one meter

(d) 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) :

(a) $\frac{1}{2}m_0v^2$

(b) $\frac{1}{2}\frac{m_0v^2}{\sqrt{(1-v^2/c^2)}}$

(c) $\frac{m_0c^2}{\sqrt{(1-v^2/c^2)}}$

(d) $\left(\frac{m_0}{\sqrt{(1-v^2/c^2)}}-m_0\right)c^2$

43. An electron and proton have the same de-Broglie wavelength. Then the kinetic energy of the electron is :

(a) zero

(b) greater than the kinetic energy of the proton

(c) less than the kinetic energy of the proton

(d) 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 :

(a) no electrons will be emitted

(b) photons are emitted

(c) electrons of higher energy are emitted

(d) 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 :

(a) same throughout the box

(b) zero throughout the box

(c) minimum in the middle

(d) 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) $\varphi_1 < \varphi_2$

(B) $\varphi_2 > \varphi_1$

(C) $\varphi_1 = \varphi_2$

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

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 themodynamics

(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) $\rho\lambda^3 >> 1$

(C) $\rho\lambda^3 << 1$

(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^{-6} 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) $\dfrac{\lambda_1\lambda_2}{2(d_2 - d_1)}$

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

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

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

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

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

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

(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 $0.8\,c$, then its relativistic kinetic energy is :

(A) $\frac{1}{2}m_0(0.8\,c)^2$

(B) $m_0c^2 - \frac{1}{2}m_0(.8\,c)^2$

(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) 2 V

(C) V

(D) $\frac{\text{V}}{2}$

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) $\frac{\hbar^2\pi^2x^2}{2m\mathrm{L}^2}$

(B) $\frac{\hbar^2\pi^2}{2m\mathrm{L}^2}$

(C) $\sqrt{\frac{2}{\mathrm{L}}}\sin\frac{n\pi x}{\mathrm{L}}$

(D) $\frac{nh}{2\pi}$

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 Å

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

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 :

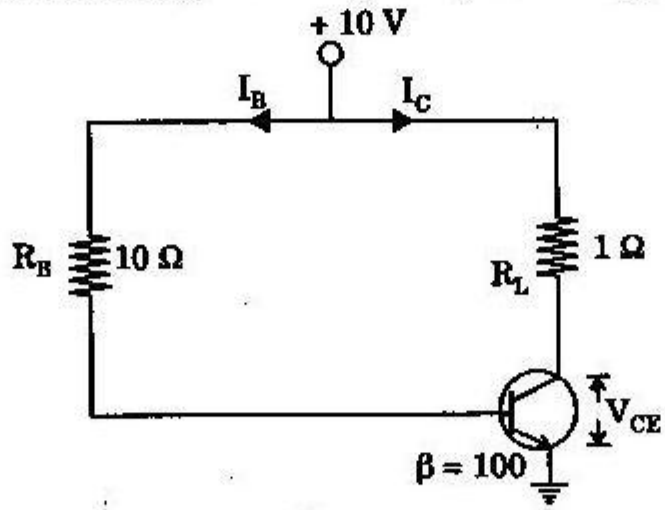
(A) doping

(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 μA

(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 paramters

(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°, 0)

   (B) (0, 90°, 180°)

   (C) (1, 90°, 0)

   (D) (0, 180°, 90°)

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) $\vec{\nabla} . \vec{A} = 0$

(C) $\vec{\nabla} \times \vec{A} = 1$

(D) $\vec{\nabla} . \vec{A} = 1$

12. If

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

where $\vec{r}$ is the positive vector, then $\nabla . \vec{A}$ 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 equitorial line are represented by E_{axial} and $E_{equ.}$ respectively, then relation between them is given by :

(A) $E_{axial} = E_{equ.}$

(B) $E_{axial} = 4E_{equ.}$

(C) $E_{axial} = 2E_{equ.}$

(D) $E_{axial} = \frac{1}{2}E_{equ.}$

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) $k = \dfrac{1 - \chi_e}{1 + \chi_e}$

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

(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) $\sqrt{\dfrac{\epsilon_0 \mu_0}{\epsilon \mu}}$

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

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

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

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/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 100 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_B-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) $\frac{ml}{2\hbar^2}$

(B) $\frac{2ml}{\hbar^2}$

(C) $\frac{\hbar^2 l}{2m}$

(D) $\frac{\hbar m^2}{2l}$

49. The nucleus ${}_{48}Cd^{115}$, after two successive β-decays will give :

(A) ${}_{46}Pa^{113}$

(B) ${}_{48}Cd^{114}$

(C) ${}_{50}Sn^{113}$

(D) ${}_{50}Sn^{115}$

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) inverversely 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 $\beta = 100$) :

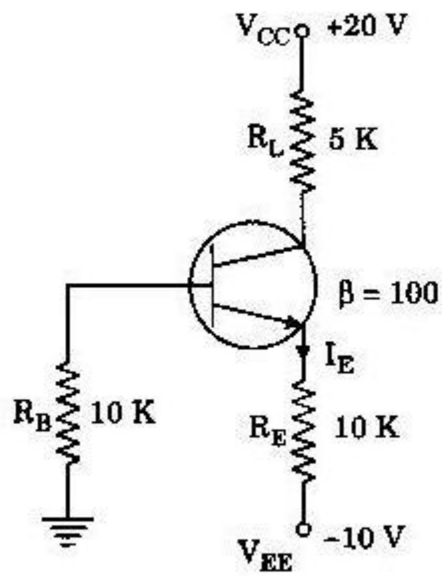


Fig.

(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