PUMDET–2017

Subject : Physics

Time Allowed : 1Hour 30 Minutes | *Maximum Marks* : 100

21300196

Booklet No. .....

INSTRUCTIONS

Candidates should read the following instructions carefully before answering the questions:

1. This question paper contains **50** MCQ type objective questions. Each question has four answer options given, viz. A, B, C and D.
2. Only one answer is correct. Correct answer will fetch full marks 2. Incorrect answer or any combination of more than one answer will fetch – ½ marks. No answer will fetch 0 marks.
3. Questions must be answered on OMR sheet by darkening the appropriate bubble marked A, B, C or D.
4. Use only **Black/Blue ball point pen** to mark the answer by complete filling up of the respective bubbles.
5. Mark the answers only in the space provided. Do not make any stray mark on the OMR.
6. Write question booklet number and your roll number carefully in the specified locations of the OMR. Also fill appropriate bubbles.
7. Write your name (in block letter), name of the examination centre and put your full signature in appropriate boxes in the OMR.
8. The OMRs will be processed by electronic means. Hence it is liable to become invilid if there is any mistake in the question booklet number or roll number entered or if there is any mistake in filling corresponding bubbles. Also it may become invalid if there is any discrepancy in the name of the candidate, name of the examination centre of signature of the candidate vis-a-vis what is given in the candidate's admit card. The OMR may also become invalid due to folding or putting stray marks on it or any damage to it. The consequence of such invalidation due to incorrect marking or careless handling by the candidate will be sole responsibility of candidate.
9. Rough work must be done on the question paper itself. Additional blank pages are given in the question paper for rough work.
10. Hand over the OMR to the invigilator before leaving the Examination Hall.

1. Imagine a toy model for a 3 state system (–0.05 eV, 0, 0.05 eV). If we define the ground state as 0 eV and shift the energy levels accordingly which of the following statements is true?

(A) The partition function stays the same but not the occupation probabilities.

(B) Both the partition function and the occupation probabilities change.

(C) Both the partition function and the occupation probabilities remain the same.

(D) The partition function changes but not the occupation probabilities.

2. The average energy per fermion (free) in 3-D at absolute zero temperature is

(A) 80 percent of Fermi energy.

(B) 60 percent of Fermi energy.

(C) 50 percent of Fermi energy.

(D) 75 percent of Fermi energy.

3. Suppose at some very early time in the history of the Universe the nucleons (protons and neutrons) are at thermal equilibrium at 10^{11} K. The relative abundance ratio of neutrons to protons at that time is

(A) 4:5

(B) 5:4

(C) 1:1

(D) Protons and neutrons would not exist as free particles.

4. At temperatures (T) much below both the Debye temperature and the Fermi temperature, the heat capacity of the metals may be written as the sum of electron and phonon contributions: $C = \gamma T + AT^3$, where γ and A are constants, characteristic of the materials. The departure of observed γ value from the calculated value for free electrons is NOT due to the interaction of the conduction electrons with

(A) the periodic potential of the rigid lattice.

(B) phonons.

(C) photons.

(D) themselves.

5. The angle between consecutive isotherm and adiabat in a Carnot cycle represented on a Temperature-Entropy diagram is

(A) 60°

(B) 90°

(C) 45°

(D) 75°

6. What is the ratio of the number of gas molecules moving with the R.M.S speed to those moving with the most probable speed at a temperature T, if the gas molecules follow a Maxwellian velocity distribution?

(A) 1.5

(B) 1.5e

(C) $1.5e^{-0.5}$

(D) $1.5e^{0.5}$

7. If a metallic material is cooled through its melting temperature at an extremely rapid rate, it will form a noncrystalline solid (i.e., a metallic glass). This will randomize the positions of the constituent atoms within the material. The electrical conductivity of the non-crystalline metal will be less than the crystalline part because

(A) of the broadening of the distribution of the free paths of the electron.

(B) of the periodicity of the distribution of the free paths of the electron.

(C) electrons in the non-crystalline case will be tightly bound to the nuclei.

(D) electrons in the non-crystalline case will be weakly bound to the nuclei.

8. Which of the following expressions for the heat capacity is incorrect? (H is enthalpy and other terms are usual)

(A) $C_P = \left(\frac{\partial H}{\partial T}\right)_P$

(B) $C_P = \left(\frac{\partial U}{\partial T}\right)_P$

(C) $C_V = \left(\frac{\partial U}{\partial T}\right)_V$

(D) $C_V = T\left(\frac{\partial S}{\partial T}\right)_V$

9. One may use the Lagrangian formalism to solve a dynamical problem because

(A) Lagrangian method deals with scalar quantities (e.g., kinetic energy and potential energy) as opposed to forces which are vectors.

(B) in Lagrangian method one need not take the forces of constraints into account.

(C) Lagrange's equation is independent of the choice of coordinate system.

(D) All of the above

10. Five point particles of equal masses are connected to each other by ten massless rigid rods in a tetrahedral shape (like a methene molecule). The number of degrees of freedom for this system is

(A) 3

(B) 4

(C) 5

(D) 6

11. The value of the line integral of the position vector $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ around the closed contour C, $\oint \vec{r}.d\vec{r}$ where C is the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ in the $z = 0$ plane, is

(A) zero

(B) $\frac{1}{6}ab$

(C) $\frac{1}{12}ab$

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

12. The Lagrangian of a dynamical system is given by

$$L=\frac{1}{2}m\dot{q}_1^2+\frac{1}{2}m\dot{q}_2^2-U(q_1)$$

where q_1 and q_2 are the two generalized coordinates and m is the mass, and U is the potential energy. Which of the following statements is true?

(A) q_1 and q_2 are both ignorable coordinate.

(B) q_1 is an ignorable coordinate but conjugate momentum corresponding to q_1 is not a constant of motion.

(C) q_2 is an ignorable coordinate and conjugate momentum corresponding to q_2 is a constant of motion.

(D) q_2 is an ignorable coordinate but conjugate momentum corresponding to q_2 is not a constant of motion.

13. A freight car leaks sand at the rate *dm/dt*. What force is needed to keep the freight car moving uniformly with velocity *v*?

(A) *-vdm/dt*

(B) zero

(C) *vdm/dt*

(D) *2vdm/dt*

14. Swami Vivekananda, standing on the rocks of Kanyakumari (Latitude 8.0883° N, Longitude 77.5385° E) observed to have no shadow at the noon of a sunny day. He was there possibly on

(A) 21st June

(B) 30th August

(C) 23rd September

(D) any day of the year

15. What is the correct statement for the following series?

(i) $1 + (1/1) + (1/2) + (1/3) + (1/4) + \ldots\ldots$

(ii) $1 + (1/1!) + (1/2!) + (1/3!) + (1/4!) + \ldots\ldots$

(iii) $1/2 + (1/2)(1/2)^2 + (1/3)(1/2)^3 + (1/4)(1/2)^4 + \ldots$

(A) Only (i) is diverging

(B) Only (ii) is converging

(C) All three are converging

(D) (i) and (iii) are converging

16. All the elements of the matrix $A = \begin{pmatrix} \alpha & \gamma \\ \delta & \beta \end{pmatrix}$ are non-zero and one of its eigenvalues is zero. Which of the following expressions is true?

(A) $\alpha\beta - \gamma\delta = 1$

(B) $\alpha\beta - \gamma\delta = -1$

(C) $\alpha\beta + \gamma\delta = 1$

(D) $\alpha\beta - \gamma\delta = 0$

17. Given the matrices $A = \frac{1}{\sqrt{2}}\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$,

$B = \frac{1}{\sqrt{2}}\begin{pmatrix} 0 & -i & 0 \\ i & 0 & -i \\ 0 & i & 0 \end{pmatrix}$ and $C = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1 \end{pmatrix}$,

which of the following expressions is true (I = unit matrix)?

(A) $AB + BA = iC$

(B) $A^2 + B^2 + C^2 = \frac{3}{4}I$

(C) $A^2 + B^2 + C^2 = 2I$

(D) $A^2 + B^2 + C^2 = I$

18. Legendre equation is given by $\left(1 - x^2\right) y'' - 2xy' + l(l+1)\, y = 0.$ Which one completely describes the regular singular points?

(A) $x = +1$ and $x = \infty$

(B) only at $x = \infty$

(C) $x = -1$ and $x = \infty$

(D) $x = \pm 1$ and $x = \infty$

19. Near to the surface of Planet X, the gravitational force on a mass m is vertically down but has magnitude mky^2, where k is a constant and y is the mass's height above the horizontal ground. Which of the following is true?

(A) The gravity of planet X is different from that on Earth but is conservative.

(B) The gravity of planet X is similar to that on Earth and is conservative.

(C) The gravity of planet X is similar to that on Earth but is not conservative.

(D) The gravity of planet X is not similar to that on Earth and is not conservative.

20. For seven datapoints the maximum degree of the interpolating polynomial will be

(A) three

(B) four

(C) six

(D) seven

21. The error involved in calculating the approximate value of the numerical derivative of $y = x^2$ at $x = 1.0$ by the central difference method is

(A) 0.0001

(B) 0.0000

(C) 0.0010

(D) –0.0010

22. What should be the value of input resistance for an ideal voltage amplifier circuit?

(A) Zero
(B) Unity
(C) Infinity
(D) Depends on the amplifier circuit

23. An intrinsic semiconductor sample of carrier concentration 10^{16} m^{-3} is doped for n-type upto a concentration of 10^{21} m^{-3}. What will be the shift in the Fermi level due to this doping at T=300 K?

(A) 0.3 ev
(B) 0.3 V
(C) 0.1 V
(D) 2.5 keV

24. 'Seven minus thirteen' in binary is

(A) 0110
(B) 10100
(C) 0111
(D) 1010

25. The GMRT radio telescope in Pune often receives signals in hermonics like 200 Hz, 250 Hz, 300 Hz. They are most likely to be comming from

(A) mobile towers
(B) lightning
(C) electrical lines
(D) near by radio stations

26. A spaceship is moving away from the earth at a speed 0.4c. A scoutship is sent to catch up with the spaceship with a speed 0.5c relative to the earth. What is the speed of the scoutship relative to the spaceship?

(A) c/2
(B) c/4
(C) c/16
(D) c/8

27. A stationary body explodes into two fragments each of mass 1.0 kg that move apart at speeds of 0.6c relative to the original body. What is the mass of the original body?

(A) 15 kg
(B) 2.5 kg
(C) 0.5 kg
(D) 10 kg

28. Consider a two-slit interference experiment in which the slits are 0.3 mm apart and the screen is 1.00 m away from the slits. The m=3 (order) bright fringe is 6 mm away from the central fringe. What is the wavelength of the light?

(A) 60 nm
(B) 550 nm
(C) 650 nm
(D) 700 nm

29. The spectral line from element X in a distant galaxy is observed at wavelength 400 nm. If the restframe wavelength of this particular line is 300 nm, at what speed is the galaxy receding from us?

(A) c/5
(B) c/7
(C) 7c/25
(D) 2c/15

30. The expression for torque on a current-carrying loop with magnetic dipole moment $\vec{p}$ in magnetic field $\vec{B}$ is $\vec{\tau} = \vec{P} \times \vec{B}$. This expression is valid for

(A) only rectangular loop
(B) only circular loop
(C) only symmetrical loop
(D) any closed loop

31. Which of the following functions satisfy the Maxwell wave equation in one dimension? (a, b, c, x_0 and d are constants and terms being usual)

(i) $a \exp\left[(b(x-vt)^2)\right]$

(ii) $b\left(x^2 - v^2 t^2\right)$

(iii) $c \tan\left(x-vt\right)$

(iv) $d / \left(x_0^2 + \left(x-vt\right)^2\right)$

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

32. The magnetic energy of a solenoid of inductance L and carrying current I is $LI^2/2$. This energy is stored in

(A) the magnetic field.
(B) the electric field.
(C) both magnetic and electric fields.
(D) the charge distribution

33. If the value of electric field at which the electrical breakdown occurs in air is 2×10^5 V/m, then what would be the minimum radius of a conducting sphere that can be raised to a potential of 10^5 V in air?

(A) 2 m
(B) 4 m
(C) 1.44 m
(D) 0.5 m

34. A carbon dioxide laser emits a sinusoidal electromagnetic wave that travels in vacuum in the negative x-direction. The wavelength of the wave is 2π μm. The electric field is parallel to the z-axis with amplitude 1.5 MVm^{-1}. Which is the correct expression for the magnetic field of the wave?

(A) $\vec{B} = \left(5\times10^{-3}\ T\right)\cos\left(10^6 m^{-1}x + 3\times10^{14}t\right)\hat{j}$

(B) $\vec{B} = \left(5\times10^{-3}\ T\right)\cos\left(10^{-6} m^{-1}x + 3\times10^{14}t\right)\hat{j}$

(C) $\vec{B} = -\left(5\times10^{-3}\ T\right)\cos\left(10^{-6} m^{-1}x + 3\times10^{14}t\right)\hat{j}$

(D) $\vec{B} = \left(1.5\times10^{6}\ T\right)\cos\left(10^{6} m^{-1}x + 3\times10^{14}t\right)\hat{j}$

35. Consider a potential $V(x) = kx^2 + ax^3$, where a and k are constants. What would be the parity of the energy eigenfunctions?

(A) The energy eigenfunctions will have odd parity.
(B) The energy eigenfunctions will have even parity.
(C) The energy eigenfunctions will have either odd or even parity.
(D) The energy eigenfunctions will not have definite parity.

36. An astrophysical plasma consists of copious free electrons with an average number density of $10^3\ m^{-3}$ and temperature 10^7 K. Which of the following is correct?

(A) The average de-Broglie wavelength of the electrons is much much less than the average distance between the electrons.
(B) The average de-Broglie wavelength of the electrons is much much high than the average distance between the electrons.
(C) The electrons in the plasma are ultra-relativistic.
(D) The energy distribution of the electrons will follow the BE statistics.

37. For every normalizable solution of the time-independent Schrodinger equation:

(A) Energy eigenvalues must be less than the minimum of the potential.
(B) Energy eigenvalues must be greater than the minimum of the potential.
(C) Energy eigenvalues must be positive definite.
(D) None of the above.

38. Consider the particle production process $K^+ + n \rightarrow \Sigma^+ + \pi^0$. Which one of the following statements is true?

(A) This process is forbidden.
(B) This process is mediated by weak interaction.
(C) This process is mediated by strong interaction.
(D) This process is mediated by electromagnetic interaction.

39. The experimentally measured lifetime of the first excited state of the $^{77}Ir_{191}$ nucleus is 1.5×10^{-10}s. The excited nucleus emits a γ-ray photon of energy 0.13 MeV in its transition to the ground state. The energy width of the first excited state is given by

(A) 1.2×10^{-4} eV

(B) 1.2×10^{-2} eV

(C) 4×10^{-6} eV

(D) 8.6×10^{-8} eV

40. Consider a planar isotropic quantum harmonic oscillator. What would be the degeneracy of the third excited state?

(A) Four

(B) Six

(C) Two

(D) Non-degenerate

41. In the radial solution of the H-atom, the probability distribution function is maximum at a radius (n is the principal quantum number and a_0 is the Bohr radius)

(A) n^2 / a_0

(B) a_0 / n^2

(C) na_0

(D) $n^2 a_0$

42. Pair production can not happen in empty space because

(A) it is a very high energy process.

(B) it will violate relativistic energy conservation.

(C) it will violate relativistic momentum conservation.

(D) it will not be able to conserve relativistic momentum and energy simultaneously.

43. Consider the rotational energy levels of the CO molecule modeled as a rigid rotor. What is the ratio of the energies of the first excited state to the second excited state

(A) $\frac{1}{3}$

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

(C) 0

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

44. Consider the first excited state of Helium atom. Which of the following statements is TRUE about the two electrons in the atom?

(A) The two electrons can not have parallel spins.

(B) The two electrons can have parallel spins.

(C) The only possibility is for electrons to have anti-parallel spins.

(D) None of the above

45. The molar specific heat of a gas is given to be $\frac{5}{2}$ R. Even if it is not specified whether that is C_p or C_v one could still conclude that the molecules of the gas

(A) are definitely monoatomic.

(B) can be monoatomic or rigid diatomic.

(C) are definitely non-rigid diatomic.

(D) are definitely rigid diatomic.

46. Two waves of the same frequency have wave vectors $\vec{k}_1 = 3\hat{i} + 4\hat{j}$ and $\vec{k}_2 = 4\hat{i} + 3\hat{j}$ respectively. They have a phase difference of ϕ at (0, 0, 0) and at $t = 0$. If the two waves have the same phase at the point (2, 7, 8) what is the phase difference between the wave at the point (3, 5, 8) at a later time t?

(A) 4 radian

(B) 2 radian

(C) 3 radian

(D) 10 radian

47. The '*slew rate*' of an operational amplifier is

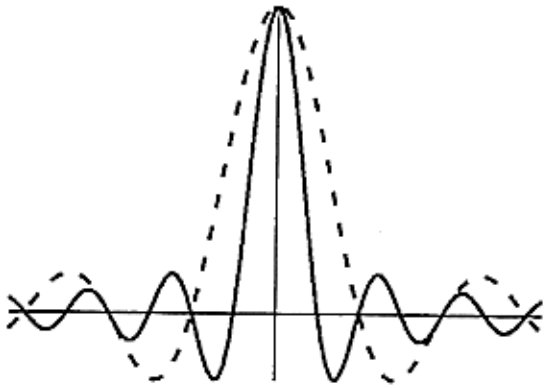
(A) independent of its frequency response.

(B) higher for wider bandwidth.

(C) lower for wider bandwidth.

(D) independent of the amplitude of the input signal.

48. Two single slit diffraction pattern are shown in the figure (λ_1 : solid line and λ_2: dashed line) for two different wavelengths. The slit-width, the distance between the slit and the viewing screen are same for both the cases. Which of the following statements is possibly true?



(A) λ_1 is red & λ_2 is green.

(B) λ_1 is ultra-violet & λ_2 is violet.

(C) λ_1 is yellow & λ_2 is violet.

(D) λ_1 is infra-red & λ_2 is red.

49. Consider a one-dimensional chain of $2N$ ions of alternating charge $\pm q$ ($N >> 1$). In addition to the Coulomb interaction, there is a repulsive potential A / R^n (A is a constant and n is a large positive integer) between nearest neighbors only. If R is the distance between nearest neighbor ions, what would be the equilibrium distance between them?

(A) $\left(\frac{Anq^2}{\ln 2}\right)^{1/(n-1)}$

(B) $\left(\frac{An}{q^2 \ln 2}\right)^{1/(n-1)}$

(C) $\left(\frac{n}{A q^2 \ln 2}\right)^{n-1}$

(D) $\left(\frac{An}{q^2 \ln 2}\right)^{n-1}$

50. In a 'peculiar' vernier scale it is observed that 10 vernier divisions coincide with 11 main scale smallest divisions. What can be said about the vernier scale?

(A) The vernier scale is wrong and can't be used to measure smaller length scale compared to smallest division of main scale.

(B) The vernier scale can be used exactly similar way as other vernier scales with vernier constant of 0.1 of main scale smallest division.

(C) The vernier scale can be used exactly similar way as other vernier scales with vernier constant of 1/11 of main scale smallest division.

(D) The vernier scale can be used in a different way as other vernier scales with vernier constant of 0.1 of main scale smallest division.