ENTRANCE EXAMINATIONS – 2018

(Ph.D. Admissions - January 2019 Session)

Ph.D. (PHYSICS)

Marks: 80

Time: 2.00 hrs. Hall Ticket No.:

I. Please enter you **Hall Ticket Number on Page 1 of this question paper and on the OMR sheet** without fail.

II. Read carefully the following instructions:

1. This Question paper has two parts: **PART - A** and **PART - B**
2. **PART - A** consists of 20 objective type questions related to Research Methods.
3. **PART - B** consists of 20 objective type questions related to Physics.
4. All questions carry two marks each.
   There is no negative marking
5. Answers are to be marked on the OMR answer sheet following the instructions provided there upon. An example is shown below

100. (A) (B) (C) ●

6. Only Scientific Calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.
7. Hand over the OMR sheet at the end of the examination to the invigilator.

This book contains 16 pages

III. Values of physical constants:
$c = 3 \times 10^8$ m/s; $h = 6.63 \times 10^{-34}$ J.s; $k_B = 1.38 \times 10^{-23}$ J/K
$e = 1.6 \times 10^{-19}$ C; $\mu_o = 4\pi \times 10^{-7}$ Henry/m; $\epsilon_o = 8.85 \times 10^{-12}$ Farad/m
$m_e = 9.1 \times 10^{-31}$Kg

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Blank sheets are provided for rough work at the end of this booklet.

PART - A

1. A rhombohedron is a three-dimensional figure like a cube, except its faces are not squares but rhombi. The number of symmetry planes for a rhombohedron, is

   A. 9

   B. 1

   C. 4

   D. 3

2. In a lucky draw competition, the tickets are numbered between 1 to 20. What is the probability that the ticket drawn has a number which is a multiple of 3 or 5?

   A. $\frac{9}{20}$

   B. $\frac{8}{20}$

   C. $\frac{7}{20}$

   D. $\frac{15}{20}$

3. Roma walks a distance of 3 m towards south. Then she turns to the left and walks for 8 m. After this she turns to the right and walks 3 m. At what distance from the starting point and in which direction has she moved?

   A. Approximately 10 m in the South East direction.

   B. Approximately 10 m in the South West direction.

   C. Approximately 14 m in the East direction.

   D. Approximately 14 m in the West direction.

4. How many squares are there on a chess board ?

   A. 64

   B. 65

   C. 204

   D. 113

5. The last digit of the second highest number, after the positions of the digits in each number of the given sequence are reversed: 738, 429, 156, 921, 175, 273, 894

   A. 4

   B. 9

   C. 8

   D. 7

6. The result of the expression $y = 1 + \cfrac{1}{1 + \cfrac{1}{1 + \cfrac{1}{1 + \cdots}}}$ is

A. $\frac{1}{2}\left(1+\sqrt{5}\right)$

B. $\frac{1}{2}\left(1+\sqrt{6}\right)$

C. $\frac{1}{2}\left(1+\frac{2}{\sqrt{3}}\right)$

D. $\frac{1}{2}\left(1+\sqrt{\frac{4}{\sqrt{3}}}\right)$

7. Estimate the temperature at which the root-mean-square velocity of nitrogen molecule in earth's atmosphere equals the escape velocity of earth's gravitational field. The mass of nitrogen molecule is 22.24 amu and the radius of earth is 6,400 km.

A. 2.8×10^{3}K

B. 1.4×10^{5}K

C. 8.2×10^{2}K

D. 6.5×10^{3}K

8. A light beam enters the top face of a glass cube of refractive index 1.5, at an angle θ to the normal. Calculate the angle at which the ray is incident on the right side of the cube and state whether the ray emerges from the right side.

A. $\cos^{-1}\left(\frac{\sin\theta}{1.5}\right)$ and the ray emerges.

B. $\cos^{-1}\left(\frac{\sin\theta}{1.5}\right)$ and the ray does not emerge.

C. $\sin^{-1}\left(\frac{\cos\theta}{1.5}\right)$ and the ray emerges.

D. $\sin^{-1}\left(\frac{\cos\theta}{1.5}\right)$ and the ray does not emerge.

9. The Riemann Zeta function can be defined in the form of a series given by

$$\zeta(p) = \sum_{n=1}^{\infty} n^{-p}$$

The series is found to be:

A. Divergent for $p \leq 1$ and convergent for $p > 1$.

B. Divergent for $p > 1$ and convergent for $p \leq 1$.

C. Divergent for all values of p.

D. Convergent for all values of p.

10. The presence of atomic hydrogen in it's lowest energy state in outer space may be detected by,

A. studying the Balmer lines.

B. measurement of the hyperfine transition in the ground state.

C. observing the ground state excitations to other allowed states.

D. collisional excitation of the ground state atoms.

11. If a thermodynamic system with fixed number of particles, volume and temperature is at equilibrium, which of the following quantites is minimized?

A. Gibbs free energy

B. Helmholtz free energy

C. Heat capacity

D. Entropy

12. The speed of an em wave propagating through a medium with dielectric constant $\epsilon = 10\epsilon_o$,(where ϵ_o is the dielectric constant in free space), is

A. $C/10$

B. $10C$

C. $\sqrt{10}\,C$

D. $C/\sqrt{10}$

13. An equation of the type $x = \tan x$ has ———— root(s)

A. Zero

B. One

C. Two

D. infinite

14. Right and left circularly polarized monochromatic light beams, with angular frequency ω and wave vector k propagating in the positive x direction, are coherently superposed. The resultant light is best described by

    A. $\cos(kx - \omega t)$

    B. $\cos(kx - \omega t) + \sin(kx - \omega t)$

    C. $\cos(kx - \omega t) + i\,\sin(kx - \omega t)$

    D. $\cos(kx - \omega t) - i\,\sin(kx - \omega t)$

15. The linewidth of a 500 nm laser, having longitudinal coherence length of 10 m, is given by

    A. 25×10^{-15}m

    B. 50×10^{-9}m

    C. 5000×10^{-9}m

    D. 50×10^{-15}m

16. Which one of the following wave functions corresponds to a bound state in three dimensions?

    A. $A\exp(-\alpha_1 r) + B\exp(\alpha_2 r), \quad \alpha_1,\ \alpha_2 > 0$

    B. $\exp[-(x^2+y^2+z^2)/\alpha^2]$, where α is real

    C. $\exp(ikr/r), \quad k > 0$

    D. $\exp[-(x^2+y^2-z^2)/\alpha^2]$ where α is real

17. Let ψ_1 and ψ_2 represent states of a system with definite energies E_1 and E_2 respectively. In the state $\psi = \alpha_1\psi_1 + \alpha_2\psi_2$, a measurement of energy will yield

    A. sometimes a value E_1 and sometimes a value E_2.

    B. a value between E_1 and E_2.

    C. $E_1 - E_2$.

    D. $\alpha_1^2 E_1 + \alpha_2^2 E_2$.

18. Consider a system described by the Hamiltonian $H(p_i, q_i, t)$. If $A(p_i, q_i, t)$ and $B(p_i, q_i, t)$ are two conserved quantities, defined on the phase space of this sytem, which of the following statements is correct?
    ([A,B] stands for the Poisson bracket of A and B)

    A. $[A, B] = 0$ always and AB is conserved.

    B. $[A, B]$ and AB are both conserved.

    C. $[A, B]$ is not conserved but AB is.

    D. Both $[A, B]$ and AB are not conserved.

19. The dimensions of the Poynting vector are

A. energy/(time × area)

B. energy/(time × volume)

C. (energy × time)/volume

D. (energy × volume)/time

20. If the wavelength of an electromagnetic wave is about the size of the diameter of an apple, what type of radiation is it?

A. X-ray

B. infrared

C. radio wave

D. microwave

PART - B

21. The value of the integral $\int_C \frac{e^z}{\sin z}$, where C is the circle $|z - \pi| = 1$ oriented counterclockwise, is

A. $2\pi i(e^{\pi} + e^{2\pi})$

B. $2\pi i e^{\pi}$

C. $-2\pi i e^{\pi}$

D. $-2\pi i(e^{\pi} + e^{2\pi})$

22. A particle undergoes Brownian motion in a liquid whose diffusion coefficient is D. The mean squared displacement of the particle after a time t, is

A. $6Dt$

B. $6D\sqrt{t}$

C. $6D^2t^2$

D. $6Dt^2$

23. The Maxwell's distribution for velocities of molecules is given by $N(v)dv = 2\pi N(m/2\pi kT)^{3/2}v^2 \exp(-mv^2/2kT)dv$. The value of $< 1/v >$ is

A. $(2m/\pi kT)^{1/2}$

B. $(2m/\pi kT)^{3/2}$

C. $(3m/\pi kT)^{1/2}$

D. $(3m/\pi kT)^{3/2}$

24. A train of identical rectangular pulses of magnitude A and duration d, denoted by the function $f(t)$ over one period, is given by

$$f(t) = \begin{cases} A & -\frac{d}{2} < t < \frac{d}{2} \\ 0 & -\frac{T}{2} < t < -\frac{d}{2}. \end{cases}$$

The frequency spectra corresponding to $f(t)$ is

A. $\frac{Ad}{T} \sin\left(\frac{n\omega d}{2}\right)$

B. $\frac{Ad}{T} \frac{\sin(n\omega d)}{n\omega d}$

C. $\frac{2Ad}{T} \frac{\sin(n\omega d/2)}{n\omega d}$

D. $\frac{2Ad}{T} \frac{\sin(n\omega d)}{n\omega d}$

25. Given the commutator $[x, p_x] = i\hbar$, value of the commutator $[x^5, p_x]$ is equal to

A. $i\hbar x^5$

B. $5i\hbar x$

C. $i\hbar(x^2 + p_x^2)$

D. $5i\hbar x^4$

26. Consider the equation

$$x(x-1)\frac{d^2y}{dx^2} + 3x\frac{dy}{dx} + y = 0\,.$$

The recurrence relation corresponding to the series solution of this equation is

A. $a_{n+1} = \dfrac{n}{n+k}\, a_n$

B. $a_{n+1} = \left(\dfrac{n+k+1}{n+k}\right) a_n$

C. $a_{n+1} = \dfrac{(n+k+1)}{(n+k+1)(n+k+2)}\, a_n$

D. $a_{n+1} = \dfrac{n+k}{(n+k+1)(n+k+2)}\, a_n$

27. A one dimensional harmonic oscillator is prepared in terms of its energy eigenstates as $|\psi\rangle = N\,(3\,|100\rangle + 4\,|3\rangle + 12\,|0\rangle)$, where N is the normalization constant. The probability of a measurement of energy giving an energy equal to $\frac{7}{2}\hbar\omega$ is

A. $\frac{4}{\sqrt{13}}$

B. $\frac{3}{\sqrt{13}}$

C. $\frac{4}{13}$

D. $\frac{4}{169}$

28. In a standard Young's double slit interference experiment, light of wavelength $\lambda = 5000\mathring{A}$ is incident on the slits. When a thin film of transparent material is put behind one of the slits, the zero order fringe shifts to the position previously occupied by the 4th order bright fringe. The thickness of the film, given that its refractive index is 1.2, is

A. 4 μm

B. 10 μm

C. 15 μm

D. 20 μm

29. How much heat (in eV) must be added to a system at 27°C for the number of accessible states to increase by a factor of 10^8?

A. 0.477 eV

B. 0.162 eV

C. 1.357 eV

D. 2.863 eV

30. Transitions of an atomic electron from a p to an s state take place, when the atom is in a weak magnetic field. The number of transitions observed would be,

A. Three

B. Ten

C. Six

D. Four

31. The independent solutions of the equation

$$\frac{d^2y}{dx^2} - 3y\frac{dy}{dx} + 2y = 0$$

are

A. e^{2x} and e^{x}.

B. e^{2x} and e^{-x}.

C. $\frac{1}{x}$ and x^2.

D. $\sin 2x$ and $\cos x$.

32. The value of the integral $I = \int_{-1}^{1} e^x dx$, computed using Simpson $\frac{1}{3}$ rule, is

A. 1.54

B. 2.36

C. 2.94

D. 4.52

33. Which of the following hydrogen atom eigenstates $|n, l, m>$ is not an eigenstate of the parity?

A. $|4, 1, 1>$

B. $\frac{1}{\sqrt{2}}|4, 1, 1> + \frac{1}{\sqrt{2}}|4, 1, 0>$

C. $\frac{1}{\sqrt{2}}|4, 1, 1> + \frac{1}{\sqrt{2}}|4, 0, 0>$

D. $\frac{1}{\sqrt{2}}|4, 1, 1> + \frac{1}{\sqrt{2}}|4, 3, 1>$

34. Two positive nuclei, each of charge q approach each other. The magnitude of the charge on the electrons placed exactly between the nuclei so that a molecule is formed can not be less than

A. $q/2$

B. $q/4$

C. q

D. $q/3$

35. The energy of the charge carriers in the valence band of a simple cubic metal has the form $E = Ak^2 + B$. Here $A = 10^{-38}\text{Jm}^{-2}$, k is the magnitude wave vector and B is a constant. The value of m^*/m is

A. 0.8

B. 0.2

C. 0.6

D. 1.0

36. The simplified expression for the given boolean function

$$F(A, B, C, D) = \sum(5, 6, 11, 12)$$

with don't care condition

$$d(A, B, C, D) = \sum(0, 1, 2, 9, 10, 14, 15),$$

in the product of sums form is

A. $AC + C\overline{D} + \overline{A}\,\overline{C}D + AB\overline{D}$

B. $AC + \overline{C}D + ABD + ACD$

C. $(\overline{A} + \overline{C})(\overline{C} + D)(A + C + \overline{D})(\overline{A} + \overline{B} + D)$

D. $(\overline{A} + \overline{C})(\overline{C} + \overline{D})(\overline{A} + \overline{C} + \overline{D})(\overline{A} + \overline{B} + \overline{D})$

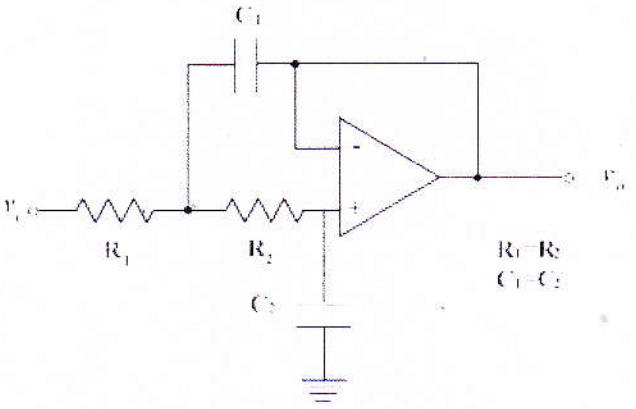
37. The Opamp circuit shown below acts as

A. low pass active filter

B. low pass passive filter

C. high pass active filter

D. band pass active filter



38. The decay process $\Lambda \to p + \pi^-$ is

A. forbidden because angular momentum is not conserved

B. forbidden because energy is not conserved

C. an example of weak decay

D. an example of strong decay

39. The change in isospin in the decay process $\Sigma^\circ \to p + \pi^-$ is

A. $\Delta I = 0$

B. $|\Delta I| = \frac{1}{2}$

C. $|\Delta I| = 1$

D. $|\Delta I| = 3/2$

40. A cylindrical laser cavity of length d, placed between two end mirrors M_1 and M_2, contains an amplifying medium with gain coefficient α. The reflectivity of mirror M_2 is 50%. For light leaving M_1 and reflecting off M_2, the intensity at M_1 has changed by a factor

A. $\frac{e^{2\alpha d}}{2}$

B. $2e^{2\alpha d}$

C. $\frac{e^{\alpha d}}{2}$

D. $2e^{\alpha d}$