PHYSICAL SCIENCE
Paper - II

Signature of Invigilators

Roll No. ☐☐☐☐☐

(In figures as in Admit Card)

1. .... **Dec-08/02**

Roll No. ....

2. ....

....

(in words)

Name of the Areas/Section (if any) ....

Time Allowed : 75 Minutes]

[Maximum Marks : 100

Instructions for the Candidates
1. Write your Roll Number in the space provided on the top of this page.
2. This paper consists of **fifty (50)** multiple choice type questions. All questions are compulsory.
3. Each item has upto four alternative responses marked (A), (B), (C) and (D). The answer should be a capital letter for the selected option. The answer letter should entirely be contained within the corresponding square.

   Correct method [A]   Wrong method [A̸   OR   [A̸

4. Your responses to the items for this paper are to be indicated on the ICR Answer Sheet under Paper II only.
5. Read instructions given inside carefully.
6. Extra sheet is attached at the end of the booklet for rough work.
7. You should return the test booklet to the invigilator at the end of paper and should not carry any paper with you outside the examination hall.

પરીક્ષાર્થીઓ માટે સૂચનાઓ :

૧. આ પાનાની ટોચમાં દર્શાવેલી જગ્યામાં તમારો રોલનંબર લખો.

૨. આ પ્રશ્નપત્રમાં બહુવૈકલ્પિક ઉત્તરો ધરાવતા કુલ **પચાસ (૫૦)** પ્રશ્નો આપેલા છે. **બધા જ પ્રશ્નો ફરજિયાત છે.**

૩. પ્રત્યેક પ્રશ્ન વધુમાં વધુ ચાર બહુવૈકલ્પિક ઉત્તરો ધરાવે છે. જે (A), (B), (C) અને (D) વડે દર્શાવવામાં આવ્યા છે. પ્રશ્નનો ઉત્તર કેપીટલ સંજ્ઞા વડે આપવાનો રહેશે. ઉત્તરની સંજ્ઞા આપેલ ખાનામાં બરાબર સમાઈ જાય તે રીતે લખવાની રહેશે.

   ખરી રીત : [A]   ખોટી રીત : [A̸   ,   [A̸

૪. આ પ્રશ્નપત્રના જવાબ આપેલ ICR Answer Sheet ના Paper II વિભાગની નીચે આપેલ ખાનાઓમાં આપવાના રહેશે.

૫. અંદર આપેલ સૂચનાઓ કાળજીપૂર્વક વાંચો.

૬. આ બુકલેટની પાછળ આપેલું પાનું રફ કામ માટે છે.

૭. પરીક્ષા સમય પૂરો થઈ ગયા પછી આ બુકલેટ જે તે નિરીક્ષકને સોંપી દેવી. કોઈપણ કાગળ પરીક્ષા ખંડની બહાર લઈ જવો નહીં.

PHYSICAL SCIENCE
Paper–II

Note : This paper contains **FIFTY (50)** Multiple-choice/Assertion and Reasoning/Matching questions, each question carrying **two (2)** marks. Attempt **ALL** the questions.

નોંધ : આ પ્રશ્નપત્રમાં **પચાસ (૫૦)** બહુવિકલ્પીય પ્રશ્નો, સાચું-ખોટું અને જોડકાં બનાવવાના પ્રશ્નો છે. તમામ પ્રશ્નોના જવાબ લખવાના છે. પ્રત્યેક પ્રશ્નના **બે (૨)** ગુણ છે.

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1. The trace of N × N unit matrix is :

   (A) 0

   (B) N^2

   (C) 2N

   (D) N

2. The average value of sin mx . cos nx over a period is :

   (A) 0

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

   (C) 1

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

3. If 1 kg of a substance is fully converted into energy, the total amount of energy (in Joule) could be :

   (A) 9×10^{20} J

   (B) 9×10^{16} J

   (C) 3×10^{8} J

   (D) 3×10^{10} J

4. If the total energy (Kinetic energy T and Potential energy V) of the particle is conserved, then :

   (A) T is constant

   (B) V is constant

   (C) T + V is constant

   (D) T – V is constant

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[P.T.O.]

5. The unit of Lagrangian is the unit of :

   (A) Force

   (B) Angular momentum

   (C) Energy

   (D) Linear momentum

6. A particle moves along an ellipse under the action of a central force. If the centre of the ellipse is the force centre for a constant K, then force $\vec{F}$ acting on the particle is :

   (A) $-K\vec{r}$

   (B) $-K\dfrac{\vec{r}}{r^3}$

   (C) $-K\left|\vec{r}\right|^2$

   (D) $-K\dfrac{\vec{r}}{r^2}$

7. In the process of scattering the total cross-section represents the number of particles scattered in :

   (A) Forward direction

   (B) Backward direction

   (C) All the directions

   (D) Cone of scattering

8. Considering small oscillations the total number of modes of vibrations for the CO_2 molecule are :

   (A) 2

   (B) 3

   (C) 6

   (D) 9

9. In theory of special relativity the Lorentz transformations are merely :

   (A) Orthogonal transformations of four-dimensional space

   (B) Non-orthogonal transformations of four-dimensional space

   (C) Orthogonal transformations of three-dimensional space

   (D) Non-orthogonal transformations of three-dimensional space

10. The potential of electric quadrupole varies as :

    (A) $\dfrac{1}{r}$ (B) $\dfrac{1}{r^2}$

    (C) $\dfrac{1}{r^3}$ (D) $\dfrac{1}{r^4}$

11. A point charge situated at a distance s from the centre of grounded conducting sphere of radius R, the force of attraction between the charge and the sphere is :

    (A) $\dfrac{1}{4\pi \epsilon_0} \dfrac{q\,q'}{(s-a)^2}$ (B) $\dfrac{1}{4\pi \epsilon_0} \dfrac{q\,q'}{s^2}$

    (C) $\dfrac{1}{4\pi \epsilon_0} \dfrac{q\,q'}{a^2}$ (D) $\dfrac{1}{4\pi \epsilon_0} \dfrac{q\,q'}{(s+a)^2}$

    where q' is the image charge placed at distance of a to the right of the center of the sphere.

12. Electrostatic force between the parallel plates of a capacitor, separated by a distance s is proportional to :

(A) c

(B) c^2

(C) $\dfrac{dc}{ds}$

(D) $\dfrac{d^2c}{ds^2}$

13. Skin depth of electromagnetic radiation varies with frequency as :

(A) $\dfrac{1}{f}$

(B) $\dfrac{1}{f^2}$

(C) $\sqrt{f}$

(D) $\dfrac{1}{\sqrt{f}}$

14. Power radiated by oscillating point charge is proportional to :

(A) v

(B) v^2

(C) a

(D) a^2

where v is velocity and a is acceleration of the point charge.

15. If the magnetic monopoles exist, which of these equations would have to be modified ?

(i) Curl $\vec{H} = \vec{J} + \dfrac{\partial \vec{D}}{\partial t}$

(ii) Curl $\vec{E} = \dfrac{-\partial \vec{B}}{\partial t}$

(iii) div $\vec{D} = \rho$

(iv) div $\vec{B} = 0$

(A) only (iv)

(B) only (ii) and (iv)

(C) only (ii)

(D) all of these

16. A long co-axial cable of length l carries current I which flows down the surface of inner cylinder of radius a and back along the outer cylinder of radius b. Self inductance of a cable is :

(A) $\dfrac{\mu_0 \, I}{2\pi \, a^2}$

(B) $\dfrac{\mu_0 \, l}{2\pi} \ln \dfrac{b}{a}$

(C) $\dfrac{\mu_0 \, l}{2\pi} \ln \dfrac{(b+a)}{(b-a)}$

(D) $\dfrac{\mu_0 \, l}{2\pi} \ln \dfrac{b^2}{a^2}$

17. If an infinite plane carries a uniform surface charge σ, its electric field varies as :

(A) $\dfrac{1}{r}$

(B) $\dfrac{1}{r^2}$

(C) $\dfrac{1}{r^3}$

(D) independent of r

18. The energy transported by electromagnetic fields per unit area per unit time is :

(A) $\dfrac{1}{2} \, \epsilon_0 \, E^2$

(B) $\dfrac{1}{2} \dfrac{B^2}{\mu_0}$

(C) $\dfrac{1}{2} \left(\epsilon_0 \, E^2 + \dfrac{B^2}{\mu_0} \right)$

(D) $\dfrac{1}{\mu_0} \left(\vec{E} \times \vec{B} \right)$

19. In a good conductor magnetic field lags the electric field by :

(A) $0°$

(B) $90°$

(C) $180°$

(D) $45°$

20. The wavefunction of a particle is given by :

$$\Psi = e^{i(kx - \omega t)}.$$

The x component of momentum of the particle is :

(A) $\hbar\omega$

(B) $\hbar k$

(C) zero

(D) $\dfrac{\hbar\omega}{c}$

21. The de Broglie wavelength of matter waves associated with an electron accelerated by a voltage of 150 V is of the order of :

(A) 0.1 Å

(B) 1 Å

(C) 10 Å

(D) 100 Å

22. 'Photon' has all the properties except one and which is :

(A) it has zero rest mass

(B) it has zero intrinsic momentum

(C) it has an integral spin

(D) its total energy is kinetic

23. If the uncertainty in position is of the order of 1 Å, the order of uncertainty in momentum (gm-cm/sec) will be :

(A) 10^{-19}

(B) 10^{-27}

(C) 10^{-35}

(D) None of these

24. The curve between the potential energy and distance between two oscillating mass points of a harmonic oscillator is :

(A) semicircle

(B) hyperbola

(C) parabola

(D) none of these

25. The angular momentum of an atomic electron is :

(A) quantized in magnitude only

(B) quantized in direction only

(C) quantized in magnitude and direction

(D) not quantized

26. For a spherically symmetric probability cloud of an electron :

(A) principle quantum number is zero

(B) orbital quantum number is zero

(C) spin quantum number is zero

(D) none of the above quantum number is zero

27. The exact expression for the operator $\left[x^2 \dfrac{d}{dx}\right]^2$ is :

(A) $x^4 \dfrac{d^2}{dx^2} + 2x^2 \dfrac{d}{dx} + 1$

(B) $x^4 \dfrac{d^2}{dx^2} + 2x^2 \dfrac{d}{dx} - 1$

(C) $x^3 \dfrac{d^2}{dx^2} + 2x^2 \dfrac{d}{dx}$

(D) $x^4 \dfrac{d^2}{dx^2} + 2x^3 \dfrac{d}{dx}$

28. If $L_\pm = L_x \pm iL_y$, then $[L_z, L_-] = ?$

(A) $-L_-$

(B) $-L_+$

(C) L_+

(D) L_-

29. An atomic state of hydrogen is represented by the following wave function :

$$\psi\,(r, \theta, \varphi) = \frac{1}{\sqrt{8\pi}} \left(\frac{1}{a_0}\right)^{3/2} \left(1 - \frac{r}{2a_0}\right) e^{\frac{-r}{2a_0}}$$

where a_0 is a constant. The quantum numbers of the state are :

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

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

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

(D) $n = 3, l = 2, m = 0$

30. The Fermi Golden Rule expresses :

(A) transition matrix element

(B) probability per unit volume

(C) density of states

(D) probable transition rate

31. Phase space trajectory of a particle thrown vertically in a constant gravitational field is :

(A) Straight line

(B) Parabola

(C) Ellipse

(D) Hyperbola

32. A system is represented by a grand canonical ensemble. Which of the following is *true* ?

   (A) system does not exchange energy with the surrounding

   (B) system exchanges energy and particles with the environment

   (C) system exchanges energy but does not exchange particles with the environment

   (D) system exchanges particles but not the energy

33. Rayleigh Jeans law for blackbody radiation can be obtained from Planck's radiation law. Which of the following assumption is necessary ?

   (A) $\dfrac{h\nu}{RT} << 1$

   (B) $\dfrac{h\nu}{RT} >> 1$

   (C) system has to be described by Quantum mechanics

   (D) system cannot be described by Newtonian mechanics and has to be described by reletivistic mechanics

34. Which of the following will be able to display Bose-Einstein condensation ?

   (A) Photons

   (B) Free electron gas

   (C) He^4 gas

   (D) Mercury at low temperature

35. A quantity of water is completely converted in the steam by boiling :

   (A) This is second order phase transition

   (B) At the boiling point the chemical potential in the vapour phase is less than that in the liquid phase

   (C) The entropy of the steam is greater than that of a water

   (D) The boiling temperature would increase if the boiling is done under the decreased pressure

36. At low temperature the specific heat of insulating crystal varies as :

   (A) AT^3

   (B) $BT + CT^3$

   (C) $Dexp(E/T)$

   (D) Constant

37. A system can be identified as a negative temperature system if :

   (A) its entropy increases with increase in internal energy

   (B) its entropy descreases with increase in internal energy

   (C) its entropy reaches maximum value

   (D) its entropy is independent of internal energy

38. A classical ideal gas restricted to region of two dimensions, that is it can move freely in two dimensions, while the third-dimension, its motion is not allowed. Then v_{rms} is given by :

   (A) $\sqrt{\dfrac{kT}{m}}$

   (B) $\sqrt{\dfrac{2kT}{m}}$

   (C) $\sqrt{\dfrac{3kT}{m}}$

   (D) $\sqrt{\dfrac{kT}{2m}}$

39. According to Fermi Dirac statistics, the probability P(E) for occupied Fermi states at absolute zero is :

(A) zero

(B) 1

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

(D) undetermined

40. Which of the following is *not* a function of thermodynamical state ?

(A) Internal energy

(B) Heat absorbed by a system

(C) Entropy

(D) Helmotz free energy

41. Leakage resistance of a capacitor is :

(A) very low

(B) zero

(C) high

(D) infinity

42. The pump which can be classified as momentum transfer pump is :

(A) diffusion pump

(B) cryo pump

(C) rotary pump

(D) water pump

43. Stopping potential of a metal :

    (A) decreases linearly with increase in work function

    (B) increases linearly with increase in work function

    (C) neither increases nor decreases with increase in work function

    (D) is proportional to the square of work function

44. If a hydrogen atom is initally at rest and its ground state energy is
    –13.6 eV, then the wavelength it emits when it transists from the 2nd to
    1st orbit will be :

    (A) 60.5 nm   (B) 121 nm

    (C) 240 nm   (D) 323 nm

45. At 4.2 K :

    (A) Electrical conductance of mercury drops to zero

    (B) Thermal conductance of mercury drops to zero

    (C) Electrical conductance tends to infinity

    (D) Thermal conductance tends to infinity

46. β-ray can be detected by :

    (A) Photo-diode   (B) Scintillation detector

    (C) GM Counter   (D) Photomultiplier

47. Arrange the following in terms of increasing temperature :

   (1) Melting point of iron

   (2) Liquid He temperature

   (3) Liquid Nitrogen temperature

   (4) Melting point of ice

   (A) (2), (3), (4), (1)   (B) (1), (2), (3), (4)

   (C) (4), (1), (2), (3)   (D) (3), (1), (4), (2)

48. What is the conversion time for 16-bit Successive Approximation ADC if the clock used is 2 MHz ?

   (A) 0.5 microseconds   (B) 16 microseconds

   (C) 8 microseconds   (D) 65, 535 microseconds

49. Which of the following sources produces Coherent light ?

   (A) CFL Bulb

   (B) He–Ne Laser

   (C) 60 Watt Tungsten Filament Bulb

   (D) Sodium Lamp in Laboratory

50. A CRO has 50 small divisions on X-Axis and 40 small divisions on Y-Axis. What is the resolution in frequency measurement and voltage measurement ?

   (A) 2% and 2.5%   (B) 50% and 40%

   (C) 4% and 5%   (D) 40% and 50%

ROUGH WORK