Signature of Invigilators

1. ....

2. ....

Roll No. | | | | | |

(In figures as in Admit Card)

PHYSICAL SCIENCES

Paper II

Roll No. ....

....

(In words)

J—0202

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 A question should entirely be contained within the corresponding square.

   Correct method [A] Wrong Method [A or [A]
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. One 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 માટેની સૂચનાઓ :

૧. આ પાનાની ટોચમાં દર્શાવેલી જગ્યામાં તમારો રોલ નંબર લખો.

૨. આ પ્રશ્નપત્રમાં કૂલ **પચાસ (50)** બહુવિકલ્પીય ઉત્તરો ધરાવતા પ્રશ્નો આપેલા છે. **સભી** પ્રશ્ન અનિવાર્ય છે.

3. 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 : [A , [A]

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 નીરીક્ષકને સોંપી દેવી. કોઈપણ પેપર પરીક્ષા રૂમની બહાર લઈ જવું નહી.

PHYSICAL SCIENCES
PAPER II

Note :—This paper contains *fifty* **(50)** multiple-choice questions, carrying **two (2)** marks each. Attempt *all* the questions.

1. Which of the following is *not* an eigenvalue of the matrix :

$$\begin{pmatrix} i & -i & 0 \\ 0 & 1 & i \\ 0 & 0 & -i \end{pmatrix}$$

(A) 1 (B) $-i$ (C) $+i$ (D) -1

2. The sum, the difference and the cross product of two vectors $\vec{A}$ and $\vec{B}$ are all mutually perpendicular to one another, if

(A) $\vec{A}$ and $\vec{B}$ are $\perp$ to each other with $|\vec{A}| = |\vec{B}|$

(B) $\vec{A}$ and $\vec{B}$ are $\perp$ to each other with $|\vec{A}| \neq |\vec{B}|$

(C) $|\vec{A}| = |\vec{B}|$ and their directions are arbitrary

(D) $|\vec{A}| = |\vec{B}|$ and they make an angle of 60°

3. What is the magnitude and phase of the complex number defined by

$$\sum_{n=1}^{3} \left(\cos \frac{2\pi n}{3} + i \sin \frac{2\pi n}{3} \right) ?$$

(A) 3, 0° (B) $\sqrt{3}$, 120° (C) 0, 0° (D) $\sqrt{3}$, 0°

4. The equation of motion for a body falling through atmosphere is

$$m \frac{d^2x}{dt^2} + b \frac{dx}{dt} + mg = 0.$$

Then, the terminal speed is given by :

(A) g/m (B) g/b (C) mg/b (D) g^2/b

5. If A and B are vectors, then :

(A) A . (A × B) = A × (A . B)

(B) A . (A × B) = (A × A) . B = 0

(C) A . (A × B) = A × (A . B) = 0

(D) A × (A × B) = A . (A . B) = 0

6. If A is an antisymmetric matrix and A^T is its transpose, which of the following is wrong ?

(A) $A^T = -A$

(B) $AA^T = A^TA$

(C) A^2 is an antisymmetric matrix

(D) A^2 is a symmetric matrix

7. A particle is moving in a straight line along $x = a$ $(a \neq 0)$ with constant velocity. The angular momentum of the particle about the origin :

(A) cannot be defined

(B) is zero

(C) is nonzero but constant

(D) is nonzero and varies with time

8. Two particles of masses m_1 and m_2 move under the influence of gravitational field of each other. No external force is present. Which of the following equations is correct, if $\vec{A}_1$ and $\vec{A}_2$ are the accelerations of the two masses ?

(A) $m_1 \vec{A}_1 + m_2 \vec{A}_2 = 0$

(B) $\vec{A}_1 = \vec{A}_2$

(C) $m_1 \vec{A}_1 = m_2 \vec{A}_2$

(D) $\vec{A}_1 = \vec{A}_2 = 0$

9. The Lagrangian defining the motion of a charged particle in an electromagnetic field with potentials ϕ and $\vec{A}$ is

(A) $\frac{1}{2} mr^2 \left(\dot{\theta}^2 + \sin^2\theta \, \dot{\phi}^2 \right) - \phi$

(B) $\frac{1}{2} m \left(\dot{r}^2 + r^2 \dot{\theta}^2 + \dot{z}^2 \right) - \phi$

(C) $\frac{1}{2} m \vec{v}^2 + q\phi - \frac{q}{c}\left(\vec{A} . \vec{v} \right)$

(D) $\frac{1}{2} m \vec{v}^2 - q\phi + \frac{q}{c}\left(\vec{A} . \vec{v} \right)$

10. If q_k is a cyclic co-ordinate, then :

(A) $H = H(q_1, q_2, \ldots\ldots, q_n, p_1, p_2, \ldots\ldots, p_n, t)$

(B) $L = L(q_1, q_2, \ldots\ldots, q_n, \dot{q}_1, \dot{q}_2, \ldots, \dot{q}_n, t)$

(C) $H = H(q_1, q_2, \ldots\ldots, q_{k-1}, q_{k+1}, \ldots\ldots, q_n, p_1, p_2, \ldots, p_{k-1}, \alpha, p_{k+1}, \ldots, p_n, t)$

(D) $L = L(q_1, q_2, \ldots\ldots, q_n, \dot{q}_1, \dot{q}_2, \ldots, \dot{q}_{k-1}, \dot{q}_k, \dot{q}_{k+1}, \ldots, q_n, t)$

11. A satellite is orbiting earth in an elliptic orbit with maximum and minimum distances from the centre of earth as L_{max} and L_{min}, respectively. In order to make the satellite orbit circular with radius equal to L_{max}, one has to provide thrust to the satellite. Which of the following is a proper thrust ?

(A) retarding thrust when the satellite is at L_{max}

(B) retarding thrust when the satellite is at L_{min}

(C) accelerating thrust when the satellite is at L_{max}

(D) thrust in radial direction at L_{max}

12. The electrical energy obtained, ideally, by annihilation of 1 gm of matter is :

(A) 5.6×10^{32} eV (B) 9.1×10^{20} eV

(C) 5.5×10^{20} J (D) 9.1×10^{32} J

13. The dispersion relation of lattice waves in a one-dimensional solid can be expressed as

$$w = w_0 \sin \frac{1}{2} ka.$$

(A) The group velocity will be greater than phase velocity irrespective of wavelength

(B) The group velocity will be equal to phase velocity for all wavelengths

(C) The group velocity will be smaller than phase velocity for all wavelengths

(D) The group velocity will be larger or smaller than phase velocity depending upon the wavelength

14. A lightening strikes earth at $x = 20$ km. A car is moving on earth along X-axis with speed 0.6 times the speed of light. The car is found to be at the origin on earth at the same time as lightening, in earth's frame. According to an observer in the car, the lightening struck the earth (assuming earth to be an inertial frame) :

(A) before he reached the origin on earth

(B) after he passed the origin on earth

(C) when he was at the origin on earth

(D) the information given is incomplete to draw any conclusion

15. A rod of copper of length 1 metre moves with a speed 0.6 times the speed of light ($\gamma = 1.25$) c in $+ x$ direction, and a particle moves with speed 0.6 times the speed of light in $- x$ direction, both in the same inertial frame S. How much time will the particle take to cross the rod in the same frame S ?

(A) $\frac{1.36}{1.2\,c}$ (B) $\frac{1}{1.25\,(1.2\,c)}$

(C) $\frac{1.25}{1.2\,c}$ (D) $\frac{1.36}{1.25\,(1.2\,c)}$

16. Under Lorentz transformation, which is invariant ?

(A) threshold photon energy in photoelectric effect

(B) Poynting vector $\vec{E} \times \vec{H}$ of electromagnetic radiation from a star

(C) Doppler shift

(D) Line element of energy-momentum four vector

17. A charged particle with charge $+q$ and velocity $\hat{i}v_x + \hat{j}v_y$ $(v_x \neq 0, v_y \neq 0)$ enters a magnetic field $\hat{k}B$. After entering the field :

(A) both v_x and v_y would remain constant

(B) v_x would change, but v_y remains constant

(C) v_y would change, but v_x remains constant

(D) both v_x and v_y would change

18. A photon, an electron and a neutron have the same wavelength. If E_p is the energy of photon, and E_e and E_n are the kinetic energies of electron and neutron, respectively, then :

(A) $E_p > E_e > E_n$

(B) $E_n > E_e > E_p$

(C) $E_e > E_n > E_p$

(D) $E_p > E_n > E_e$

19. A constant, uniform current is flowing through a wire. At the surface, the Poynting vector is pointing :

(A) along the direction of current

(B) opposite to the direction of current

(C) radially inside

(D) radially outside

20. Potential of a spherically symmetric charge distribution is given by :

$$V(r) = \frac{V_0}{2}(3 - r^2/R^2), \quad r < R$$
$$= V_0\frac{R}{r}, \quad r > R.$$

The charge distribution ρ then can be described by :

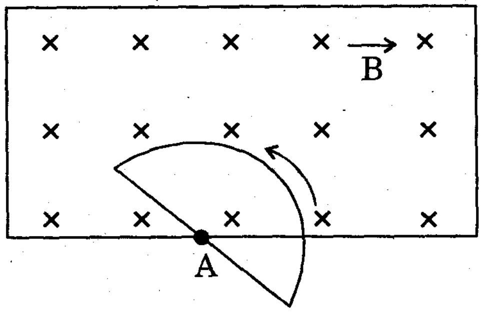
(A) ρ = constant for $r < R$, $\rho = 0$ for $r > R$

(B) $\rho \propto r$ for $r < R$, $\rho \propto 1/r$ for $r > R$

(C) $\rho = 0$ for $r < R$, ρ = constant for $r > R$

(D) $\rho \propto e^{-r/R}$ for all r

21.



A uniform and constant magnetic field $\vec{B}$ is directed perpendicularly into the plane of the page everywhere within a rectangular region as shown above. A wire circuit in the shape of a semicircle is uniformly rotated counterclockwise in the plane of the page about an axis at A. The axis is $\perp$ to the page at the edge of the field, and is at the centre of straight line portion of the wire. The e.m.f. generated is best described by :

(A) triangular wave

(B) sinusoidal wave

(C) exponentially damped sinusoidal wave

(D) square wave

22. For a uniform plane e.m. wave propagating in free space, one observes characteristically that :

(A) the ratio $\left(\vec{E}/\vec{H}\right)$ is equal to $\sqrt{\mu_0}/\sqrt{\epsilon_0}$ ohms

(B) $\vec{E}$ and $\vec{H}$ are in phase

(C) $\vec{E}$ and $\vec{H}$ bear a definite ratio, E/H = magnitude of energy flowing

(D) $\vec{E} \times \vec{H}$ is $\perp$ to the direction of propagation

23. A small current element dl metres long, carrying a current of 1 coulomb per second, produces at a distance of 1 metre from the element and $\perp$ to it, a magnetic field given by :

(A) dl. $\mu_0/4\pi$ (B) 1 T

(C) dl. 3×10^8 gauss (D) 10^{-7} T

24. If $\vec{P}$ is the polarisation vector and $\vec{E}$ the electric field, then the polarizability α defined by

$$\vec{P} = \alpha \vec{E}$$

[$\vec{P}$ and $\vec{E}$ are not in the same direction]
is :

(A) a scalar
(B) a vector
(C) a numerical constant
(D) a tensor

25. The intensity of radiation emitted by an isotropic dipole oscillating in X-direction is zero along :

(A) X-direction
(B) Y-direction
(C) Z-direction
(D) no direction

26. The ϕ-dependence of wavefunction of a particle in central force field is given by

$$e^{\pm im\phi}$$

Here m has to be an integer because of the requirement that :

(A) the wavefunction has to be continuous
(B) derivative of the wavefunction has to be continuous
(C) the wavefunction has to be single valued
(D) the wavefunction has to be finite

27. At $t = 0$, a one-dimensional harmonic oscillator of angular frequency w is in a state given by

$$\psi(x, 0) = \frac{3}{5} u_0(x) + \frac{4}{5} u_1(x),$$

where u_0 and u_1 are the first two normalised eigenfunctions. The average energy of the oscillator is :

(A) $\hbar w$
(B) $2\hbar w$
(C) $1.14\hbar w$
(D) $1.4\hbar w$

28. The following function cannot represent a correct wavefunction of a particle,

$$\left.\begin{array}{ll} Ae^{X/X_0} & \text{for } X < 0, \\ \dfrac{AX_0}{(X + X_0)} & \text{for } X > 0, \end{array}\right\} X_0 > 0$$

because :

(A) it diverges at $X = +\infty$
(B) it diverges at $X = -X_0$
(C) it is not continuous at $X = 0$
(D) its derivative is not continuous at $X = 0$

29. A particle moves in an infinite square well

$$V = 0 \text{ for } |x| < a$$
$$V = \infty \text{ for } |x| > a$$

$\psi_0, \psi_1, \ldots\ldots\ldots\ldots$ are its energy eigenfunctions with ψ_0 being the ground state. A small perturbing potential $V' = \epsilon$ for $|x| < a/2$ and $V' = 0$ for $|x| > a/2$ is introduced. Then the new ground state wavefunction ψ_0' is best described by :

(A) $\psi_0' = a_{00}\psi_0, \quad a_{00} \neq 0$

(B) $\psi_0' = \sum_{n=0}^{\infty} a_{0n}\psi_n$ with $a_{0n} = 0$ for all odd values of n

(C) $\psi_0' = \sum_{n=0}^{\infty} a_{0n}\psi_n$ with $a_{0n} = 0$ for all even values of n

(D) $\psi_0' = \sum_{n=0}^{\infty} a_{0n}\psi_n$ with $a_{0n} \neq 0$ for all n

30. If L_+ and L_- are angular momentum ladder operators, then the value of the commutator

$$[L_+, L_-]$$

is :

(A) $L_+^2 + L_-^2$ (B) $2\hbar L_z$ (C) L^2 (D) zero

31. For a finite well potential in three dimensions,

$$V(r) = -V_0 \quad \text{for } r < R, \text{ and}$$
$$V(r) = 0 \quad \text{for } r > R.$$

Which of the following is true ?

(A) there always exists at least one bound state and it has angular momentum equal to zero

(B) number of bound states are always infinite

(C) it is possible that there exists no bound state for the problem

(D) all bound states have angular momentum equal to zero

32. The degeneracy of the first excited state of a three-dimensional harmonic oscillator is :

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

33. The potential described by

$$V(x) = \infty \qquad \text{for } x < 0$$

$$V(x) = \frac{1}{2}kx^2 \qquad \text{for } x > 0,$$

then the ground state energy of a particle in terms of $w = \sqrt{\frac{k}{m}}$ is :

(A) $\frac{1}{2}\hbar w$ (B) $\hbar w$ (C) $\frac{3}{2}\hbar w$ (D) $\frac{5}{2}\hbar w$

34. A system containing two identical particles is described by a wavefunction of the form

$$\psi = \frac{1}{\sqrt{2}}\left[\psi_\alpha(x_1)\,\psi_\beta(x_2) + \psi_\beta(x_1)\,\psi_\alpha(x_2)\right],$$

where x_1 and x_2 represent spatial co-ordinates, and α_1 and α_2 represent all the quantum numbers including spin. The particles must be :

(A) positrons (B) electrons

(C) protons (D) α-particles

35. A particle of mass 10^{-27} kg moving with speed 10^7 m/s in + X direction encounters a slit of width 1 Å in Y-direction. According to the Uncertainty Principle, it could acquire a velocity in Y-direction which is of the order of (take $\hbar \sim 10^{-34}$ J.S) :

(A) 10^{-3} m/s (B) 1 m/s (C) 10^3 m/s (D) 10^6 m/s

36. In a first order phase transition :

(A) chemical potential and its first derivative are continuous

(B) chemical potential is continuous while its first derivative is discontinuous

(C) chemical potential is discontinuous while its first derivative is continuous

(D) chemical potential and its second derivative are discontinuous

37. ^{3}He and ^{4}He :

(A) both obey Fermi-Dirac statistics

(B) ^{3}He obeys BE statistics, while ^{4}He obeys FD statistics

(C) both obey Bose-Einstein statistics

(D) ^{3}He obeys FD statistics, while ^{4}He obeys BE statistics

38. The energy equation for a fluid, viz.,

$$dU = T\,dS - p\,dV$$

results that :

(A) the equilibrium state need not be characterised by minimal dU

(B) the internal energy is only a function of entropy S and volume V

(C) a fluid can be transported, quasi-statically, since $dH = dU + p\,dV$

(D) $\left.\frac{\partial T}{\partial V}\right|_S = -\left.\frac{\partial p}{\partial S}\right|_V$

39. If the temperature of a black body is doubled, the total energy radiated would increase by a factor of :

(A) 32 (B) 16 (C) 8 (D) 4

40. If Debye temperature of solid A is twice that of solid B, the ratio of lattice specific heats

$$C_V|_A / C_V|_B$$

at low temperatures, assuming Debye's theory, would be given by :

(A) 8 (B) 1/8 (C) 4 (D) 1/4

41. Which one of the following statements is *true* ?

(A) Both Einstein and Debye models give $C_V \to 3R$ at high temperatures

(B) Both Einstein and Debye models give $C_V \propto T^3$ at low temperatures

(C) In Einstein's model $C_V \propto T^3$ at low temperatures but not so in Debye's model

(D) In Debye's model $C_V \to 3R$ at high temperatures but not so in Einstein's model

42. A system consisting of N_0 subsystems is in thermal equilibrium at temperature T. The system can exist only in two energy states E_1 and E_2. If N_0 is very large and $(E_2 - E_1) = \epsilon > 0$, then the average number of systems in the state of energy E_1 is given by :

(A) $\frac{1}{2} N_0$

(B) $\frac{N_0}{1 + e^{-\epsilon/kT}}$

(C) $N_0 e^{-\epsilon/kT}$

(D) $\frac{1}{2} N_0 e^{-\epsilon/kT}$

43. The Hall coefficient for metals is always :

(A) negative

(B) positive

(C) independent of mobility of charge carriers

(D) dependent on the concentration of charge carriers

44. The temperature of liquid hydrogen can be measured by :

(A) thermocouple (B) optical pyrometer

(C) vapour pressure thermometer (D) bolometer

45. A photomultiplier tube works on :

(A) emission of secondary electrons

(B) emission of photons

(C) emission of photoelectrons

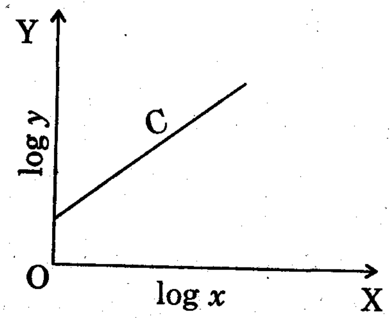
(D) emission of secondary photons

46. In experiments on diffraction by solids, the energy of particles involved is 0.1 eV. This refers to :

(A) X-ray diffraction (B) electron diffraction

(C) neutron diffraction (D) optical diffraction

47.



Which one of the following equations best represents the above curve C ?

(A) $xy = a$ (B) $y = ax^m$

(C) $y = ax^2 + b$ (D) $y = e^x + a$

48. If length can be measured with an accuracy of ± 1 percent, with what accuracy the volume of a cube can be measured ?

(A) ± 6% (B) ± 3% (C) ± 2% (D) ± 1%

49. The signal

$$e(t) = 5 \sin 2\pi \, . \, 500t$$

can be sampled without aliasing error by a sampling frequency given by :

(A) 5000 Hz (B) 500 Hz (C) 600 Hz (D) 900 Hz

50. In oil rotary pump for low vacuum, the oil primarily serves :

(A) as a lubricant

(B) to isolate rotating and stationary members of the pump

(C) to discharge the exhaust against atmospheric pressure

(D) to prevent air from leaking back into the pump side

ROUGH WORK

ROUGH WORK

SEAL