Signature of Invigilators

1. .....

2. .....

Roll No. | | | | | |

(In figures as in Admit Card)

PHYSICAL SCIENCES

Paper II

Roll No. .....

.....

(In words)

D—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' 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 માટે સૂચનાઓ :

૧. આ પૃષ્ઠના ઉપલા ભાગે આપેલી જગ્યામાં તમારી ક્રમાંક સંખ્યા (રોલ નંબર) લખો.

૨. આ પ્રશ્નપત્રમાં **૫૦ (પચાસ)** બહુવૈકલ્પિક ઉત્તરોવાળા પ્રશ્નો છે. **બધા જ** પ્રશ્નોના ઉત્તરો આપવા ફરજિયાત છે.

૩ પ્રત્યેક વિગતના (A), (B), (C) અને (D) એવા ચાર સંભવિત ઉત્તરો આપવામાં આવ્યા છે. તમે સ્વીકારેલા વિકલ્પનો ઉત્તર કેપિટલ (પહેલી એબીસીડી) અક્ષરમાં આપવાનો રહેશે.તમારા ઉત્તર આપેલા ચોરસમાં સરખી રીતે લખવા.

   સાચી પદ્ધતિ : [A] ખોટી પદ્ધતિ : [A] , [A]

૪. આ પ્રશ્નપત્રના ઉત્તરો આઈસીઆરના ઉત્તરપત્રકમાં Paper II ની નીચે લખવાના રહેશે.

૫. અંદર આપેલી સૂચનાઓ ધ્યાનથી વાંચો.

૬. આ ઉત્તરપોથીને અંતે આપેલું પૃષ્ઠ કાચા કામ માટે છે.

૭. પ્રશ્નપત્ર લખાઈ રહે એટલે આ ઉત્તરપોથી તમારા નિરીક્ષકને આપી દેવી. પરીક્ષાખંડની બહાર કોઈપણ પ્રશ્નપત્ર લઈ જવું નહીં.

SEAL

PHYSICAL SCIENCES

PAPER II

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

1. Which one of the following is a scalar quantity ?

   (A) Area (B) Pressure

   (C) Moment of Inertia (D) Potential Energy

2. Considering $i^2 = -1$, the value of $\sqrt{i}$ could be :

   (A) 1 (B) $\frac{1}{\sqrt{2}} + \frac{i}{\sqrt{2}}$

   (C) $i/\sqrt{2}$ (D) $-1 + i$

3. The result of scalar triple product $\vec{\nabla}.\vec{\nabla} \times \vec{V}$ is :

   (A) $\nabla^2\vec{V}$ (B) $\vec{\nabla}.\vec{V}$

   (C) $\vec{\nabla} \times \vec{V}$ (D) 0

4. The Fourier series of an odd function $f(t)$ of period T is :

   (A) Fourier cosine series (B) Fourier transform

   (C) Fourier sine series (D) Not possible

5. The number of independent solutions of a given third order differential equation is :

   (A) 3 (B) 6

   (C) 9 (D) Infinite

6. A charge q_1 is fixed at the origin of coordinates. If another charge q_2 is placed at a distance r from q_1, and if the electrostatic potential is taken to be zero at a point s from q_1 and if this point lies between the line joining q_1 and q_2, then the electrostatic energy of q_2 is :

   (A) $-\frac{q_1q_2}{s} + \frac{q_1q_2}{r}$ (B) $\frac{q_1q_2}{s} + \frac{q_1q_2}{r}$

   (C) $\frac{q_1q_2}{r}$ (D) $\frac{q_1q_2}{r}\left[1 + \left(\frac{r}{s}\right)^2\right]$

7. The kinetic energy of a particle in terms of coordinates r and $q = \sin\theta$, where r and θ are polar coordinates, is :

(A) $\frac{1}{2}m\left(\dot{r}^2 + r^2\dot{q}^2\right)$ (B) $\frac{1}{2}m\left(\dot{r}^2 + \frac{r^2\dot{q}^2}{1-q^2}\right)$

(C) $\frac{1}{2}m\left(\dot{r}^2q^2 + r^2\dot{q}^2\right)$ (D) $\frac{1}{2}m\left(\dot{r}^2 + r^2\theta^2\dot{q}^2\right)$

8. The Lagrangian

$$L = \frac{1}{2}m\dot{x}^2 + ax\dot{x}t,$$

where m is the mass of the particle and a is constant, describes the motion of the particle under potential energy V proportional to :

(A) x (B) $\frac{1}{x}$

(C) x^2 (D) $\frac{1}{x^2}$

9. The total energy of a particle moving in an attractive inverse square force field is given by

$$E = \frac{1}{2}m\dot{r}^2 - \frac{k}{r} + \frac{l^2}{2mr^2}, \; k > 0.$$

The turning points of the motion are given by :

(A) $E = 0$ (B) $r = \frac{l^2}{2mk}$

(C) $E = -\frac{k}{r} + \frac{l^2}{2mr^2}$ (D) $l = 0$

10. A beam of charged pions leaves an accelerator target at a speed of $0.99\,c$. The half-life of pions is 1.77×10^{-8} s. The beam intensity will drop to half its original intensity at the following distance from the target :

(A) 5.3 m (B) 39 m

(C) 530 m (D) 390 m

11. The dispersion relation of a wave is given by

$$w(k) = c\sqrt{k^2 + k_0^2},$$

where c and k_0 are constants. The group and phase velocities respectively are :

(A) $\frac{c^2k}{w}, \frac{w}{k}$ (B) $\frac{w}{k}, \frac{c^2k}{w}$

(C) $\frac{c}{2}, c$ (D) $\frac{w^2}{ck^2}, \frac{c^2k}{w^2}$

12. A point particle is scattered by a rigid sphere of radius R. The total scattering cross-section is :

(A) $16\pi R^2$ (B) $2\pi R^2$

(C) $4\pi R^2$ (D) πR^2

13. Listed below are four Maxwell's equations of electromagnetism. If magnetic monopoles exist, which of these would need modifications ?

(*i*) $\vec{\nabla} \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$ (*ii*) $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

(*iii*) $\vec{\nabla} \cdot \vec{D} = \rho$ (*iv*) $\vec{\nabla} \cdot \vec{B} = 0$

(A) Only (*iv*) (B) (*i*) and (*ii*)

(C) (*i*) and (*iii*) (D) (*ii*) and (*iv*)

14. If an electric field is given in a certain region by $E_x = 0$, $E_y = 0$, $E_z = kz$, where k is a nonzero constant, which of the following is *true* ?

(A) There is a charge density in the region

(B) There is a time-varying magnetic field associated with it

(C) The electric field cannot be constant in time

(D) This electric field is impossible

15. A circular loop of radius R, carrying a current I, lies in X-Y plane with its centre at the origin. The total magnetic flux in the x-y plane is :

(A) Directly proportional to I (B) Directly proportional to R

(C) Inversely proportional to R (D) Zero

16. Which of the following is *not* part of Maxwell's equations ?

(A) $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$ (B) $\vec{\nabla} \cdot \vec{E} = \rho / t_0$

(C) $\vec{\nabla} \cdot \vec{B} = 0$ (D) $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$

17. A charged particle of mass m enters a region of uniform magnetic field $\vec{B}$ with velocity $\vec{v}$ making an angle of 30° with the direction of the magnetic field. The path of such a particle is :

(A) Circular (B) Parabolic

(C) Helical (D) Sinusoidal

18. The scalar and vector potentials are given by

$$\Phi = 0, \vec{A} = a(ct - |X|)^2 \hat{k}, \quad |X| < ct$$

$$= 0 \quad , \quad |X| > ct$$

where a is a constant. The electric field then is :

(A) $-(ct - |X|)\hat{k}$, $|X| < ct$; 0, $|X| > ct$

(B) 0, $|X| < ct$; $-(ct - |X|)\hat{k}$, $|X| > ct$

(C) $-2ac(ct - |X|)\hat{k}$, $|X| < ct$; 0, $|X| > ct$

(D) Zero

19. The frequency of a television transmitter is :

(A) 100 kHz (B) 1 MHz

(C) 10 MHz (D) 100 MHz

20. If a charged particle q is moving in a circular path of radius R under the action of a constant magnetic field B, then its momentum is given by :

(A) $\frac{p^2}{2m} = \frac{1}{2\mu_0}B^2$ (B) $p = qBR$

(C) $p = \frac{1}{qBR}$ (D) $p = \sqrt{qBR}$

21. Total power radiated by an accelerated charge is proportional to (a = acceleration) :

(A) a (B) a^{-2}

(C) a^{-1} (D) a^2

22. The wave vector k of propagation of electromagnetic wave in a plasma is given by :

$$k^2 = \frac{1}{C^2}(\omega^2 - \omega_p^2),$$

where ω_p is the constant plasma frequency. The group velocity is given by :

(A) $\frac{C}{\left(1 - \frac{\omega_p^2}{\omega^2}\right)^{1/2}}$ (B) $C\left(1 - \frac{\omega_p^2}{\omega^2}\right)$

(C) $C\frac{\omega}{\omega_p}$ (D) $C\left(1 - \frac{\omega_p^2}{\omega^2}\right)^{1/2}$

23. Which one of the following is an admissible wave function of a particle ?

(A) $\frac{1}{x^2 + a^2}$ (B) e^{ax}

(C) e^{-ax} (D) x^2

24. Which one of the following is an eigen function of linear momentum operator in one dimension with a positive eigenvalue $\hbar k$?

(A) $\cos kx$ (B) $\sin kx$

(C) e^{kx} (D) e^{ikx}

25. A system is known to be in the normalized state described by the wave function

$$\psi(\theta, \varphi) = \frac{1}{\sqrt{30}} \left\{5Y_4^3 + Y_6^3 - 2Y_6^0\right\},$$

where $Y_l^m(\theta, \varphi)$ are the spherical harmonics. The probability density of finding the system in a state with azimuthal quantum number $m = 3$ is :

(A) 0 (B) 1/15

(C) 13/15 (D) 1/6

26. The number of degenerate states for the first excited state of hydrogen atom is :

(A) 2 (B) 3

(C) 4 (D) 9

27. The spherical harmonics $Y_{lm}(\theta, \varphi)$ are the eigen functions of :

(A) L^2 and L_z (B) L_x, L_y and L_z

(C) $\vec{L}$ and L_z (D) L^2 and L_x

28. In the Hamiltonian of anharmonic oscillator

$$H = \frac{p^2}{2m} + \frac{1}{2} m\omega^2 x^2 + \lambda x^4,$$

the perturbation term is :

(A) $\frac{p^2}{2m}$ (B) $\frac{1}{2} m\omega^2 x^2$

(C) $\frac{1}{2} \hbar\omega$ (D) $\lambda\, x^4$

29. For angular momentum $\bar{J}$, in the quantum mechanical context the value of the commutator $[(J_x + J_y + J_z), J^2]$ is :

(A) 0 (B) $i\hbar J_x$

(C) $i\hbar J_y$ (D) $i\hbar J_z$

30. If R and T are the reflection and transmission coefficients of particles incident on a potential barrier, one can expect :

(A) $R = T$ (B) $R + T = 0$

(C) $R + T = 1$ (D) $T = 1$

31. In the first Born approximation, the scattering amplitude is :

(A) Real (B) Complex

(C) Imaginary (D) Zero

32. The total wave function of a system of N electrons is :

(A) Symmetric

(B) $N \times N$ determinant

(C) $(N - 1) \times (N + 1)$ determinant

(D) N determinants

33. Consider the two isotopes ^3He and ^4He. Bose-Einstein condensation will take place in :

(A) both the isotopes (B) Neither

(C) ^3He (D) ^4He

34. Which law of thermodynamics states that at $T = 0$, $S = 0$:

(A) Zeroth law (B) First law

(C) Second law (D) Third law

35. If the Debye temperature of a solid is 2500 K, then at 27°C the specific heat :

(A) will be that given by Dulong-Petit's law

(B) will be less than that given by Dulong-Petit's law

(C) will be more than that given by Dulong-Petit's law

(D) will follow Einstein's theory

36. Four fermions are to be distributed amongst five energy states including spin. The number of possible ways for such distribution is :

(A) Four (B) Eight

(C) Ten (D) Five

37. A vessel contains 7 balls. The number of ways in which we can first draw 2 balls, then 3 balls and finally 2 balls from the vessel is :

(A) $\frac{7!}{2!\ 3!}$ (B) $\frac{7!}{5!}$

(C) $\frac{7!}{3!\ (2!)^2}$ (D) $\frac{7!}{5!\ 2!}$

38. A closed thermodynamic cycle is described in a clockwise direction in the P-V diagram with volume V plotted along the X-axis and pressure p along the Y-axis. The work done by the system, the heat energy absorbed by the system and the change in the internal energy of the system are, respectively :

(A) Negative, positive, zero (B) Positive, negative, zero

(C) Positive, zero, negative (D) Positive, positive, zero

39. The entropy S of a system is related to the number, Ω, of microscopic states accessible to the system by (K = Boltzmann const.) :

(A) $S = \ln \Omega$ (B) $S = K \ln \Omega$

(C) $S \ln \Omega = K$ (D) $S = \frac{1}{\ln \Omega}$

40. The ratio of specific heat at constant pressure and at constant volume of an ideal diatomic gas, when no vibrational degrees of freedom are excited, is :

(A) 7/5 (B) 5/3

(C) 9/7 (D) 9/5

41. The pressures of ideal Bose and Fermi gases at absolute zero are, respectively :

(A) Zero, Zero

(B) Zero, Non-zero

(C) Non-zero, Zero

(D) Non-zero, Non-zero

42. A photomultiplier can detect a feeble optical signal because of :

(A) The shape of its photocathode

(B) Multiplication of the output pulse

(C) Multiplication of secondary electrons

(D) Multiplication of photons

43. Precise value of h/e can be obtained by :

(A) Thomson's method (B) Millikan's method

(C) Bragg's method (D) Compton effect

44. Diffraction pattern for different isotopes will be different for :

(A) X-ray Diffraction (B) Electron Diffraction

(C) Optical Diffraction (D) Neutron Diffraction

45. Hall coefficient of 5 mm wide and 1 mm thick strip of InSb was found to be 4×10^{-4} m^3c^{-1}. When it is placed in a field of IT Hall voltage was found to be 40.7 mV for 100 mA current passing along the sample. For the same amount of current if width is doubled and thickness is halved, then the voltage will be :

(A) 40.7 mV (B) 81.4 mV

(C) 20.35 mV (D) 10.17 mV

46. For low pressure measurement between $10^{-8} - 10^{-11}$ torr, the suitable gauge is :

(A) Thermocouple gauge (B) McLeod gauge

(C) Penning gauge (D) Hot cathode gauge

47. The operation of an ionization chamber is comparable to that of a :

(A) Scintillation detector (B) Proportional counter

(C) Solid state detector (D) G. M. counter

48. Pulse height analysis cannot be used with :

(A) Proportional counters (B) G. M. counters

(C) Scintillation detectors (D) HpGe detectors

49. Standard deviation is a measure of :

(A) Goodness of fit

(B) Reproducibility of measurement

(C) Time dependence of measurement

(D) Deviation from the standard value

50. A charged particle in a magnetic field :

(A) gains energy (B) loses energy

(C) does not gain energy (D) gains momentum

ROUGH WORK

ROUGH WORK

SEAL