Test Booklet Code & Serial No.
प्रश्नपत्रिका कोड व क्रमांक

B

Paper-II
PHYSICAL SCIENCE

Signature and Name of Invigilator

1. (Signature) .....

(Name) .....

2. (Signature) .....

(Name) .....

Seat No. | | | | | | |

(In figures as in Admit Card)

Seat No. .....

(In words)

OMR Sheet No. | | | | | | |

(To be filled by the Candidate)

APR - 32217

Time Allowed : 1¼ Hours] **[Maximum Marks : 100**

Number of Pages in this Booklet : **16**

Number of Questions in this Booklet : **50**

Instructions for the Candidates

1. Write your Seat No. and OMR Sheet No. in the space provided on the top of this page.
2. This paper consists of **50** objective type questions. Each question will carry *two* marks. *All* questions of Paper-II will be compulsory, covering entire syllabus (including all electives, without options).
3. At the commencement of examination, the question booklet will be given to the student. In the first 5 minutes, you are requested to open the booklet and compulsorily examine it as follows :
   (*i*) To have access to the Question Booklet, tear off the paper seal on the edge of this cover page. Do not accept a booklet without sticker-seal or open booklet.
   (*ii*) **Tally the number of pages and number of questions in the booklet with the information printed on the cover page. Faulty booklets due to missing pages/ questions or questions repeated or not in serial order or any other discrepancy should not be accepted and correct booklet should be obtained from the invigilator within the period of 5 minutes. Afterwards, neither the Question Booklet will be replaced nor any extra time will be given. The same may please be noted.**
   (*iii*) After this verification is over, the OMR Sheet Number should be entered on this Test Booklet.
4. Each question has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.
   Example : where (C) is the correct response.

   (A) (B) ● (D)

5. Your responses to the items are to be indicated in the **OMR Sheet given inside the Booklet only.** If you mark at any place other than in the circle in the OMR Sheet, it will not be evaluated.
6. Read instructions given inside carefully.
7. Rough Work is to be done at the end of this booklet.
8. If you write your Name, Seat Number, Phone Number or put any mark on any part of the OMR Sheet, except for the space allotted for the relevant entries, which may disclose your identity, or use abusive language or employ any other unfair means, you will render yourself liable to disqualification.
9. You have to return original OMR Sheet to the invigilator at the end of the examination compulsorily and must not carry it with you outside the Examination Hall. You are, however, allowed to carry the Test Booklet and duplicate copy of OMR Sheet on conclusion of examination.
10. **Use only Blue/Black Ball point pen.**
11. **Use of any calculator or log table, etc., is prohibited.**
12. **There is no negative marking for incorrect answers.**

विद्यार्थ्यांसाठी महत्त्वाच्या सूचना

1. परिक्षार्थींनी आपला आसन क्रमांक या पृष्ठावरील वरच्या कोपऱ्यात लिहावा. तसेच आपणांस दिलेल्या उत्तरपत्रिकेचा क्रमांक त्याखाली लिहावा.
2. सदर प्रश्नपत्रिकेत **50** बहुपर्यायी प्रश्न आहेत. प्रत्येक प्रश्नास **दोन** गुण आहेत. या प्रश्नपत्रिकेतील **सर्व** प्रश्न सोडविणे अनिवार्य आहे. सदरचे प्रश्न हे या विषयाच्या संपूर्ण अभ्यासक्रमावर आधारित आहेत.
3. परीक्षा सुरू झाल्यावर विद्यार्थ्याला प्रश्नपत्रिका दिली जाईल. सुरुवातीच्या 5 मिनीटांमध्ये आपण सदर प्रश्नपत्रिका उघडून खालील बाबी अवश्य तपासून पहाव्यात.
   (*i*) प्रश्नपत्रिका उघडण्यासाठी प्रश्नपत्रिकेवर लावलेले सील उघडावे. सील नसलेली किंवा सील उघडलेली प्रश्नपत्रिका स्विकारू नये.
   (*ii*) **पहिल्या पृष्ठावर नमूद केल्याप्रमाणे प्रश्नपत्रिकेची एकूण पृष्ठे तसेच प्रश्नपत्रिकेतील एकूण प्रश्नांची संख्या पडताळून पहावी. पृष्ठे कमी असलेली/कमी प्रश्न असलेली/प्रश्नांचा चूकीचा क्रम असलेली किंवा इतर त्रुटी असलेली सदोष प्रश्नपत्रिका सुरुवातीच्या 5 मिनिटातच पर्यवेक्षकाला परत देऊन दुसरी प्रश्नपत्रिका मागवून घ्यावी. त्यानंतर प्रश्नपत्रिका बदलून मिळणार नाही तसेच वेळही वाढवून मिळणार नाही याची कृपया विद्यार्थ्यांनी नोंद घ्यावी.**
   (*iii*) वरीलप्रमाणे सर्व पडताळून पहिल्यानंतरच प्रश्नपत्रिकेवर ओ.एम.आर. उत्तरपत्रिकेचा नंबर लिहावा.
4. प्रत्येक प्रश्नासाठी (A), (B), (C) आणि (D) अशी चार विकल्प उत्तरे दिली आहेत. त्यातील योग्य उत्तराचा रकाना खाली दर्शविल्याप्रमाणे ठळकपणे काळा/निळा करावा.
   उदा. : जर (C) हे योग्य उत्तर असेल तर.

   (A) (B) ● (D)

5. या प्रश्नपत्रिकेतील प्रश्नांची उत्तरे **ओ.एम.आर. उत्तरपत्रिकेतच दर्शवावीत.** इतर ठिकाणी लिहीलेली उत्तरे तपासली जाणार नाहीत.
6. आत दिलेल्या सूचना काळजीपूर्वक वाचाव्यात.
7. प्रश्नपत्रिकेच्या शेवटी जोडलेल्या कोऱ्या पानावरच कच्चे काम करावे.
8. जर आपण ओ.एम.आर. वर नमूद केलेल्या ठिकाणा व्यतिरीक्त इतर कोठेही नाव, आसन क्रमांक, फोन नंबर किंवा ओळख पटेल अशी कोणतीही खूण केलेली आढळून आल्यास अथवा असभ्य भाषेचा वापर किंवा इतर गैरमार्गाचा अवलंब केल्यास विद्यार्थ्याला परीक्षेस अपात्र ठरविण्यात येईल.
9. परीक्षा संपल्यानंतर विद्यार्थ्याने मूळ ओ.एम.आर. उत्तरपत्रिका पर्यवेक्षकांकडे परत करणे आवश्यक आहे. तथापी, प्रश्नपत्रिका व ओ.एम.आर. उत्तरपत्रिकेची द्वितीय प्रत आपल्याबरोबर नेण्यास विद्यार्थ्यांना परवानगी आहे.
10. **फक्त निळ्या किंवा काळ्या बॉल पेनचाच वापर करावा.**
11. **कॅलक्युलेटर किंवा लॉग टेबल वापरण्यास परवानगी नाही.**
12. **चुकीच्या उत्तरासाठी गुण कपात केली जाणार नाही.**

Physical Science
Paper II

Time Allowed : 75 Minutes] **[Maximum Marks : 100**

Note : This Paper contains **Fifty (50)** multiple choice questions, each question carrying **Two (2)** marks. Attempt *All* questions.

1. Which of the following equations signifies the conservative nature of the electric field $\bar{E}$?

   (A) $\nabla.\bar{E}(\bar{r}) = \frac{\rho(\bar{r})}{\epsilon_0}$

   (B) $\nabla \times \bar{E}(\bar{r}) = \bar{0}$

   (C) $\nabla \times \bar{E}(\bar{r},t) = \frac{-\partial \bar{B}(\bar{r},t)}{\partial t}$

   (D) $\epsilon_0 \mu_0 \frac{\partial \bar{E}(\bar{r},t)}{\partial t} = \nabla \times \bar{B}(\bar{r},t) - \mu_0 \bar{J}(\bar{r},t)$

2. Plane monochromatic electromagnetic wave is propagating through a perfect dielectric material of refractive index $\frac{3}{2}$. The phase difference between the fields $\bar{E}$ and $\bar{B}$ associated with the wave passing through the material is .....

   (A) Zero

   (B) π

   (C) $\frac{3}{2}\pi$

   (D) any non-zero value between $-\pi$ and π

3. An electromagnetic wave is propagating in a dielectric medium of permittivity ϵ and permeability μ having an electric field vector $\bar{E}$ associated with the wave. The associated magnetic field $\bar{H}$ is.....

   (A) Parallel to $\bar{E}$ with magnitude $E\sqrt{\mu/\epsilon}$

   (B) Parallel to $\bar{E}$ with magnitude $E\sqrt{\epsilon/\mu}$

   (C) Perpendicular to $\bar{E}$ with magnitude $E\sqrt{\mu/\epsilon}$

   (D) Perpendicular to $\bar{E}$ with magnitude $E\sqrt{\epsilon/\mu}$

4. Power radiated by a point charge moving with constant acceleration of magnitude a is proportional to.....

   (A) a

   (B) a^2

   (C) a^{-1}

   (D) a^{-2}

5. The output of a laser has a bandwidth of 1.2×10^{14} Hz. The coherence length l_c of the output radiation is .....

(A) 3.6 mm

(B) 50 μm

(C) 2.5 μm

(D) 1.5 cm

6. Given $[x_i, P_j] = i\hbar\delta_{ij}, i, j = 1, 2, 3.$ (x_1, P_2^2) is :

(A) 0

(B) $i\hbar P_2$

(C) $2x_1$

(D) $2P_2$

7. Which of the following is an eigen state of square of linear momentum operator P_x^2 ?

(A) Ax^2

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

(C) $Ae^{-\alpha x^2}$

(D) $A\sin^2 kx$

8. The electron in a hydrogen atom is in a superposition state described by the wavefunction $\psi(\vec{r}) = A[4\psi_{100}(\vec{r}) - 2\psi_{211}(\vec{r}) + \sqrt{6}\,\psi_{210}(\vec{r}) - \sqrt{10}\,\psi_{21-1}(\vec{r})]$ $\psi_{nlm}(\vec{r})$ normalized wave function. The value of normalization constant, A, is :

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

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

(C) 6

(D) 36

9. Two coherent light sources of I and 9I are used in an interference experiment. The resultant intensity at points where the waves from the two sources superpose with phase difference π is :

(A) 16I

(B) 9I

(C) 4I

(D) Zero

10. Non-relativistic hydrogen atom spectrum is proportional to $-1/n^2$. The degeneracy of nth level is :

(A) n

(B) $2n + 1$

(C) n^2

(D) $1/n^2$

11. Uncertainty relation holds between :

(A) Time and space

(B) Life time and energy

(C) Position and energy

(D) Momentum and energy

12. Addition of angular momentum $\vec{j}_1 = 1$ and $\vec{j}_2 = \frac{1}{2}$ will result in 6 states, of which the number of linearly independent states with magnetic number $m = -\frac{1}{2}$ is :

(A) Zero

(B) 6

(C) 3

(D) 2

13. In a scattering event by a spherically symmetric potential, only P-wave scattering occurs. The angular distribution of differential cross-section is proportional to :

(A) Constant

(B) $\cos\theta$

(C) $\cos^2\theta$

(D) $a + \sin\theta$

14. If energy of a two-dimensional simple harmonic oscillator $x = \frac{p_x^2}{2m} + \frac{p_y^2}{2m} + \frac{1}{2}m\omega^2(x^2 + y^2)$ is fixed to be $3\hbar\omega$, the entropy is given by (k_B is Boltzmann constant) :

(A) k_B ln 3

(B) $2k_B$ ln 3

(C) k_B ln 2

(D) Zero

15. The equation of state for photon gas is :

(A) $pV = \frac{5}{3}E$

(B) $pV = \frac{2}{3}E$

(C) $pV = \frac{1}{3}E$

(D) $pV = \hbar\omega$ for some fixed frequency ω

16. The energy density for photons in a cavity is proportional to :

(A) T^3

(B) T

(C) T^4

(D) $T^{4/3}$

17. Let ρ be the density matrix for a system. Then :

(A) $Tr\ (\rho) = 0$

(B) $Tr\ (\rho) < 0$

(C) $0 \leq Tr(\rho) < 1$

(D) $Tr\ (\rho) = 1$

18. A system has only two energy levels E_1 and E_2. In equilibrium at temperature T, the number of particles occupying level E_1 is double of those occupying level E_2. The value of $E_2 - E_1$ must be [k = Boltzmann constant] :

(A) k T ln (2)

(B) k T ln (3)

(C) 3 k T

(D) 2 k T

19. The quantities (*i*) isothermal compressibility (*ii*) volume coefficient of expansion are :

(A) Extensive and intensive respectively

(B) Intensive and extensive respectively

(C) Both extensive

(D) Both intensive

20. The chemical potential in the classical limit is :

(A) Zero

(B) Negative

(C) Positive

(D) Complex quantity

21. van der Waals equation for one mole is $\left(p+\frac{a}{V^2}\right)(V-b)=RT.$ The equation for n moles would be :

(A) $\left(p+\frac{an^2}{V^2}\right)(V-nb)=RT$

(B) $\left(p+\frac{a^2}{V^2}\right)(V-b)=nRT$

(C) $\left(p+\frac{an^2}{V^2}\right)(V-nb)=nRT$

(D) $\left(p+\frac{a}{n^2V^2}\right)(nV-b)=nRT$

22. A Wheatstone's bridge is used to measure the pressure in the following vacuum gauge :

(A) McLeod gauge

(B) Pirani gauge

(C) Penning gauge

(D) Ionization gauge

23. The continuous X-rays are produced when :

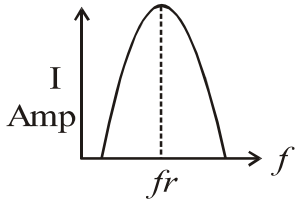
(A) Electrons of the target atom jump from a higher to lower orbital

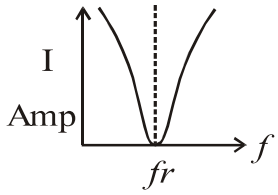
(B) Electrons from the valence electrons are de-excited to the hole in the inner orbitals

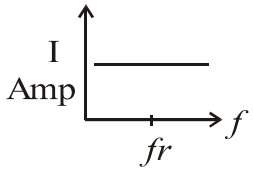
(C) Electrons are accelerated to fixed energy

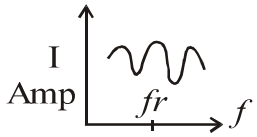
(D) Incident electrons are deaccelerated near heavy nuclei of the target atoms.

24. Which of the following curves refers to the series resonance circuit of inductance and capacitor ?

(A) 

(B) 

(C) 

(D) 

25. For detecting photons which of the following detectors is used ?

(A) Faraday Collector

(B) Channeltron

(C) Photo-multiplier

(D) Micro-channel plate

26. For obtaining a Laue pattern of a single crystal the sample is held stationary in a beam of :

(A) Monochromatic K_α X-rays from Cu target

(B) Monochromatic K_α X-rays from Mo target

(C) Monochromatic K_β X-rays from Cu target

(D) Continuous X-rays from any target

27. The transient response of an electronic circuit is tested by giving the following wave form at the input :

(A) Sinusoidal

(B) Square

(C) Triangular

(D) Saw-tooth

28. Which of the following effects manifests particle nature of light ?

(A) Photoelectric effect

(B) Black body radiation

(C) Interference

(D) Diffraction

29. A ruled grating having 1000 grooves per mm is used for diffraction. If light of wavelength 300 nm is incident at right angle and if 'θ' is the diffraction angle, sinθ for first order diffraction will be equal to :

(A) 0.1

(B) 0.3

(C) 0.2

(D) 0.5

30. A gas laser has mirrors at its ends and produces a spectrum of lines which are separated according to various orders of interference between the two mirrors. If the separation of mirrors and the wavelength of laser are 30 cm and 6000 Å respectively, the separation between two neighbouring lines is approximately :

(A) 6 Å

(B) 0.6 Å

(C) 0.06 Å

(D) 0.006 Å

31. The Fourier transform of $f(x) = \frac{1}{\pi}\frac{1}{1+x^2}$ is :

(A) $e^{-|k|}$

(B) $e^{-|k|^2}$

(C) $\frac{1}{\pi}.\frac{1}{1+k^2}$

(D) $\ln(1+k^2)$

32. A card is drawn from a pack of 52 cards. The probability that one of the cards drawn is a 'ten' or a 'jack' or a 'queen' is :

(A) 1/13

(B) 2/13

(C) 6/13

(D) 3/13

33. The matrix $\begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix}$ is :

(A) diagonalizable by an orthogonal transformation

(B) diagonalizable by a unitary transformation

(C) not diagonalizable

(D) diagonalizable by a Hermitian transformation

34. Residue of the function $f(z) = \frac{z}{(z-a)(z-b)}$ at infinity is :

(A) a/b

(B) $-b/a$

(C) 1

(D) -1

35. Determinant of a 3 × 3 real symmetric matrix is 36. Two of its eigenvalues are 2 and 3. The third eigenvalue is :

(A) 1

(B) 6

(C) 4

(D) 9

36. One of the solutions of the differential equation $\frac{d^2f}{dx^2} + 2\,\text{sech}^2 xf = 0$ is :

(A) sech x

(B) tanh x

(C) $\text{sech}^2\ x$

(D) $\text{sech}^3\ x$

37. Average value of the function $f(x) = 4x^3$ in the interval 1 to 3 is :

(A) 15

(B) 20

(C) 80

(D) 40

38. If $r = \sqrt{(x^2 + y^2 + z^2)}$, grad r $(\vec{\nabla} r)$ is :

(A) $\vec{r} / r$

(B) 0

(C) r

(D) $\vec{r}$

39. Residue of $\int_C \frac{dz}{(z - z_0)^2}$, where C is any simple closed contour enclosing z_0, is :

(A) $2\pi i$

(B) $2\pi i z_0$

(C) πi

(D) zero

40. A rigid body of N particles has the following number of degrees of freedom :

(A) 3N

(B) N

(C) 6

(D) 3

41. A particle of mass m moves in a central force field defined by $\vec{F} = (-K / r^3)\hat{r}$. If E is the total energy of the particle, then its speed is :

(A) $\frac{k}{m r^2} + \frac{2E}{m}$

(B) $\frac{k}{m r^2} - \frac{2E}{m}$

(C) $\sqrt{\frac{k}{2m r^2} + \frac{2E}{m}}$

(D) $\sqrt{\frac{k}{2m r^2} - \frac{2E}{m}}$

42. A block of mass m is sliding down an inclined plane at constant speed. The coefficient of kinetic friction between the mass and the inclined plane is 2. The angle of inclination is :

(A) $\sin^{-1}$ (1/2)

(B) $\cos^{-1}$ (1/2)

(C) $\tan^{-1}$ (1/2)

(D) $\tan^{-1}$ (2)

43. A particle of mass m under the influence of central force $\vec{F} = \frac{-k}{r^3}\hat{r}$, where k is constant. What is the potential energy of the particle if potential is zero at $r = \infty$.

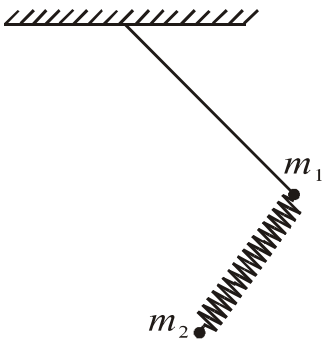
(A) $\frac{k}{2r^2}$

(B) $\frac{-k}{2r^2}$

(C) $\frac{3k}{r^4}$

(D) $\frac{-3k}{r^4}$

44. A mass is hanged from ceiling with an inextensible massless string. Another mass m_2 is hanged from m by a spring. The number of degrees of freedom of the system is :



(A) 3

(B) 5

(C) 4

(D) 6

45. A particle of mass m falls vertically under gravity and the frictional force is obtainable from dissipation function $G(v) = \frac{1}{2}kv^2$. The Lagrangian equation of motion is :

(A) $m\ddot{y} + k\dot{y} + mg = 0$

(B) $m\ddot{y} + mg = 0$

(C) $m\ddot{y} + \frac{1}{2}k\dot{y} + mg = 0$

(D) $m\ddot{y} + \frac{1}{2}k\dot{y}^2 + mg = 0$

46. A particle of mass m and charge Q is moving in a constant magnetic field of strength H along Z–axis. The Hamiltonian of the system is (in esu) :

(A) $p^2 / 2m - \frac{QH}{mc}xp_y + \frac{Q^2H^2x^2}{2mc^2}$

(B) $\frac{p^2}{2m} + \frac{QH}{mc}xp_y + \frac{Q^2H^2x^2}{2mc^2}$

(C) $\frac{p^2}{2m} + \frac{2HQ}{mc}(xp_y + yp_x)$

(D) $\frac{p^2}{2m} - \frac{2HQ}{mc}(xp_y + yp_x)$

47. A one-dimensional simple harmonic oscillator with generalized coordinate q is subject to an additional time-dependent potential energy of the form

$$V(t) = q^2 t + q\dot{q}t^2$$

The Lagrangian equations of motion contain an additional term :

(A) Containing only t

(B) Containing only t^2

(C) Containing t and t^2

(D) No additional term

48. The electric potential at a distance r from the center of the sphere of radius R having uniform surface charge density σ is equal to .....

(A) $\frac{\sigma R}{\in_0}$

(B) $\frac{\sigma R^2}{\in_0}$

(C) $\frac{\sigma R^2}{\in_0 r}$

(D) $\frac{\sigma R^2}{\in_0 r^2}$

49. A charged solid sphere of radius 3 units is made up of perfectly conducting material and is placed with center at the origin. If the total charge on the sphere is Q, the volume charge density at a point (1, 1, –1) is .....

(A) $\frac{Q}{36\pi}$

(B) $\frac{Q}{4\sqrt{3}\pi}$

(C) $\frac{3Q}{4\pi}$

(D) Zero

50. The electric potential at a large distance r from the ideal linear quadrupole varies with r as .....

(A) r^3

(B) r^4

(C) r^{-3}

(D) r^{-4}

ROUGH WORK