INDIAN ASSOCIATION OF PHYSICS TEACHERS

National Graduate Physics Examination 2026

Day and Date of Examination: Sunday, January 25, 2026

Time : 10 AM to 1 PM

<u>Instructions to Candidates</u>

1. In addition to this question paper, you are given **answer sheet (OMR Sheet) for part A** and **answer paper for part B**.
2. On the answer sheet (OMR Sheet) for part A, fill up all the entries carefully in the space provided, **Only in block capital. Do write the name and PIN of your city.**

   Incomplete / incorrect / carelessly filled information may disqualify your candidature
3. On part A answer sheet, use only BLUE or BLACK BALL PEN for making entries and marking answers.
4. In Part A each question has **FOUR** alternatives. Any number of these (4, 3, 2 or 1) may be correct. You have to mark **ALL** correct alternatives and fill a bubble (●) for each, like

Q.No.	a	b	c	d
24	○	●	○	●

   Full marks are 6 for each question, you get them only when ALL correct answers are marked. The answers of part A shall be available on **www.indapt.org** on 1.2.2026.
5. Part A answer sheet will be collected at the end of one hour.
6. Any rough work should be done only on the sheets provided with part B answer paper.
7. Use of non-programmable calculator is allowed.
8. No candidate should leave the examination hall before the completion of the examination. You will take away the question paper with you.
9. Symbols used in the paper have their usual meaning unless specified otherwise.

PLEASE DO NOT MAKE ANY MARK OTHER THAN ● IN THE SPACE PROVIDED ON THE ANSWER SHEET OF PART A MEANS YO HAVE TO DARK THE CIRCLE.

Answer sheets for part A are to be evaluated with the help of a machine. Due to this, **CHANGE OF ENTRY IS NOT ALLOWED**

Scratching or overwriting may result in wrong score

DO NOT WRITE ANYTHING ON BACK SIDE OF ANSWER SHEET FOR PART A

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Part A- Maximum Marks: 150 — Time for Part A : 60 minutes

Part B- Maximum Marks: 150 — Time for Part B : 120 minutes

Part A

$25 \times 6 = 150$

Mark the correct option/options (Any number of options may be correct).
Marks will be awarded only if all the correct options are marked. No negative marking.

1. For two vectors A and B, the component of

(a) vector A along vector B is $\left(\dfrac{\vec{A}.\vec{B}}{|B|^2}\right)\vec{B}$

(b) vector A perpendicular to Vector B is $\vec{B} \times \dfrac{\vec{A} \times \vec{B}}{|B|^2}$

(c) vector B perpendicular to Vector A is $\dfrac{\vec{A}\times\vec{B}}{|A|^2}\times\vec{A}$

(d) vector B perpendicular to the plane containing vectors A and B is zero

2. The Scalar potential (ϕ) and magnetic vector potential ($\vec{A}$) can be related with fields $\vec{E}$ and $\vec{B}$ as

(a) $\vec{E} = -\dfrac{\partial \vec{A}}{\partial t} - \text{grad}\,\phi$

(b) $\vec{B} = \text{curl}\,\vec{A}$

(c) $\vec{E} = -\,\text{grad}\,\phi$ for steady electric field

(d) Curl $\vec{A} = -$ grad ϕ

3. The ratio of the two specific heats of a gas $\gamma = \dfrac{C_P}{C_V}$ is maximum for

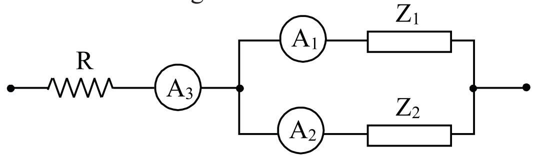
(a) monoatomic gas

(b) diatomic gas

(c) triatomic gas

(d) hexa-atomic gas

4. As a part of typical electronic circuit, two parallel branches carrying hotwire ammeters A_1 and A_2, with impedances Z_1 and Z_2 respectively. In the laboratory, the current in A_1 and A_2 is recorded to be 5 A and 12 A at a certain time. At the same time the hotwire ammeter A_3 shows a reading of



(a) 13 A, if Z_1 is an inductance and Z_2 is a resistance

(b) 17 A, if both Z_1 and Z_2 are resistances

(c) 7 A, if Z_1 is an inductance and Z_2 is a capacitance

(d) 13 A, if Z_1 is a resistance and Z_2 is a capacitance

5. An ideal diatomic gas initially at a temperature $T = 0^0$C is allowed to expand reversibly adiabatically to 5 times its initial volume. The final temperature of the gas is

(a) $-180\,°C$

(b) $-150\,°C$

(c) $-130\,°C$

(d) $0\,°C$

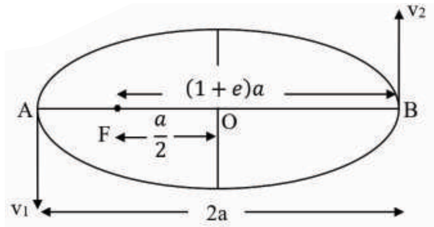
6. The largest value of the magnitude of the Compton shift is observed when the angle of scattering is
(a) zero
(b) $\frac{\pi}{4}$
(c) $\frac{\pi}{2}$
(d) π

7. The semi - empirical mass formula for the binding energy of nucleus contains a coulomb interaction energy term. This term depends on the mass number A as
(a) $A^{-\frac{1}{3}}$
(b) $A^{+\frac{1}{3}}$
(c) $A^{+\frac{2}{3}}$
(d) A

8. A plane progressive wave is travelling along the positive direction of x-axis where y and v represent the particle displacement and the speed of the wave respectively. The equation(s) of wave is/are.
(a) $\frac{\partial y}{\partial x}+\frac{1}{v}\frac{\partial y}{\partial t}=0$
(b) $\frac{\partial y}{\partial x}-\frac{1}{v}\frac{\partial y}{\partial t}=0$
(c) $\frac{\partial^2 y}{\partial x^2}+\frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}=0$
(d) $\frac{\partial^2 y}{\partial x^2}-\frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}=0$

9. For a body centred cubic (bcc) lattice, the x-ray diffraction peaks are observed for the Miller Indices ($h\ k\ l$) The possible allowed values of $h^2+k^2+l^2$ is/are
(a) 3
(b) 4
(c) 5
(d) 7

10. A Planet rotates in an elliptical orbit with a heavy star situated at one of its foci. The distance from the centre of the ellipse to either of its foci is one-half of the semi major axis (means = $\frac{a}{2}$).



The ratio of its speed (v_1) when it is nearest (at the perihelion) to the star to that (v_2) when it is the farthest (at the aphelion) from the star is
(a) 5 : 2
(b) 3 : 2
(c) 3 : 1
(d) 1 : 2

11. A microscopic particle of rest mass 2m moving with a relativistic speed v ($\approx c$) along the positive direction of x axis, collides head-on with another particle of mass m moving in opposite direction with the same speed. As a result of elastic collision, the two particles coalesce together to form a single particle of rest mass M moving in the same direction as the first particle. The mass M is expressed as
(use $\frac{v}{c}=\beta$)
(a) $M = m\sqrt{\frac{9-\beta^2}{1-\beta^2}}$
(b) $M = 2m\sqrt{\frac{3-\beta^2}{1-\beta^2}}$
(c) $M = \frac{m}{2}\sqrt{\frac{9-\beta^2}{2-\beta^2}}$
(d) $M = m\sqrt{\frac{3-\beta^2}{2-\beta^2}}$

12. A point particle is moving in an orbit in a plane with a constant angular speed ω=2 rad/sec. The radial distance of the particle from the origin at time t is expressed as $r = r_0 e^{2\beta t}$ where r_0 and β are positive constants. The numerical value of β in rad/s, for which the radial acceleration vanishes, is
(a) $\beta = +1$
(b) $\beta = -1$
(c) $\beta = +2$
(d) $\beta = -2$

13. Given that $\vec{E}$ is Electric field Vector, $\vec{P}$ is Electric Polarization Vector and $\vec{D}$ is Electric Displacement; Also ρ_f, ρ_b and χ_r are respectively the free charge density, the bound charge density and the relative electric susceptibility. Which of the following relation(s) is/are valid for a linear dielectric?
(a) $\vec{P} = \varepsilon_0 \chi_r \vec{E}$
(b) $\vec{P} = \varepsilon_0 (1+\chi_r)$
(c) $\vec{D} = \varepsilon_0 \vec{E} + \vec{P}$
(d) $\vec{\nabla} . \vec{D} = \rho_f + \rho_b$

14. The de Broglie wave length of an electron is $\lambda = 2.0$ pm. The correct statement(s) is/are
(a) The kinetic energy of the electron is 292.44 keV
(b) The energy of the electron is 803.44 keV
(c) The phase velocity of the wave associated with electron is $v_p = 1.3$ c
(d) The group velocity of the de Broglie wave is $v_g = 0.772$ c

15. A fermion of mass m free to move in two dimensions is strictly confined in a square box of side ℓ. The potential inside the square box is zero (V = 0). A measurement of the energy of the fermion results $E = \frac{65\pi^2 \hbar^2}{2m\ell^2}$ · The degeneracy of the energy state E is/are
(a) 2
(b) 3
(c) 4
(d) 5

16. A magnetic field $\vec{B}$ is expressed as $\vec{B}$ = curl $\vec{A}$ where the magnetic vector potential $\vec{A} = (ax^2 + by^2)\,\hat{i}$ The corresponding current density $\vec{J}$ is
(a) $\vec{J} = -\frac{2}{\mu_0}(a+b)\hat{i}$
(b) $\vec{J} = -\frac{2}{\mu_0}(a-b)\hat{i}$
(c) $\vec{J} = -\frac{2}{\mu_0} a\hat{i}$
(d) $\vec{J} = -\frac{2}{\mu_0} b\hat{i}$

17. The Fourier analysis of the output of a full wave rectifier fed with an alternating voltage $V = V_0 \sin\omega t$ reveals that the lowest ripple frequency is
(a) Zero
(b) ω
(c) 2ω
(d) 3ω

18. In a dielectric medium of relative permittivity $\varepsilon_r = 5$, the amplitude of displacement current (i_d) is equal to the conduction current (i) for an applied sinusoidal voltage of frequency f = 1MHz. The value of electric conductivity (σ) in units of $\Omega^{-1}m^{-1}$ of the dielectric medium at this frequency is
(a) 2.78×10^{-4}
(b) 2.78×10^{-3}
(c) 2.44×10^{-4}
(d) 2.44×10^{-3}

19 Charge +Q is uniformly distributed over the circumference of a non-conducting circular ring of radius R. The increase in the tension in the ring when another charge +q has been placed at the centre of this ring.
(a) $T = \frac{1}{8\pi^2\varepsilon_0}\frac{Qq}{R^2}$
(b) $T = \frac{1}{8\pi^2\varepsilon_0}\frac{Qq}{R^3}$
(c) $T = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{R^3}$
(d) $T = \frac{1}{4\pi^2\varepsilon_0}\frac{Qq}{R^2}$

20. The ground state energy of five identical spin $s = \frac{1}{2}$ particles which are subjected to quantum mechanical harmonic oscillator potential of angular frequency ω is

(a) $\frac{1}{2}\hbar\omega$

(b) $\frac{5}{2}\hbar\omega$

(c) $\frac{9}{2}\hbar\omega$

(d) $\frac{13}{2}\hbar\omega$

21. A radioactive sample contains two types of non-interactive) radioactive nuclei P and Q with half-life one hour and two hour respectively. Each of P and Q decay to produce stable nucleus R. Initially at t = 0 there are $4N_0$ nuclei of P and N_0 of Q but none of R. Estimate the total number of nuclei of R at a time when the number of nuclei of P and Q are left to be equal in the sample.

(a) N_0

(b) $\frac{5}{2}N_0$

(c) $\frac{7}{2}N_0$

(d) $\frac{9}{2}N_0$

22. In an experimental setup of Newton's ring, the plane glass plate is replaced by another plano-convex lens of same material with the two curved surfaces in contact, the circular interference fringes will

(a) distort to loose shape

(b) totally disappear

(c) get closer to each other

(d) move apart

23. For different relativistic parameters, the Lorentz transformation(s) from one inertial frame of reference S (at rest) to another frame S′ (moving with uniform speed v along x axis is/are correct [All the symbols have their usual meaning

(a) $x' = \dfrac{x - vt}{\sqrt{1-\frac{v^2}{c^2}}}$

(b) $p'_x = \dfrac{p_x - \frac{vE}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}$

(c) $u'_x = \dfrac{u_x - v}{1 - \frac{vu_x}{c^2}}$

(d) $\omega' = \dfrac{\omega - vk_x}{\sqrt{1-\frac{v^2}{c^2}}}$

24. A pulsed LASER beam of wavelength λ = 660 nm has an average power of 30 mW, the pulse duration of 30 ns and the pulse repetition rate of 20 Hz. The number of photons per pulse is

(a) 1.0×10^{20}

(b) 2.0×10^{18}

(c) 5.0×10^{15}

(d) 3.0×10^{9}

25. A p-n diode (ideality/quality factor η=1) is operating in forward bias at room temperature (thermal energy 26.0 meV). If the diode current is 26 mA when the applied voltage is V=1.0V, the dynamic resistance r_d and the static resistance r_s are

(a) $r_d = 1.0\ \Omega$

(b) $r_d = 2.0\ \Omega$

(c) $r_s = 38.5\ \Omega$

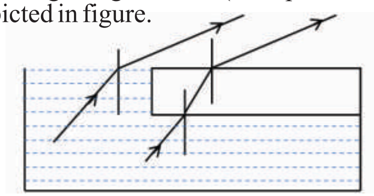
(d) $r_s = 1.0\ \Omega$

Part B1 — 10 x 5 = 50

Answer all the following in brief (not more than 10 lines) with appropriate reasoning

B1. A bowling ball is thrown down the alley in such a way that initially it slides with a speed v_0 without rolling. The solid ball will roll without any sliding when its speed falls to $v = \frac{5}{7} v_0$. The transition from sliding to rolling is gradual. Defend or refute.

B2. As shown in the figure, the two rays of light running parallel in water will come out parallel in air, even though the second ray comes through a rectangular glass slab (with parallel faces) as depicted in figure.



Given that ${}_a\mu_g = \frac{3}{2}$ & ${}_a\mu_w = \frac{4}{3}$ Defend or refute.

B3. Explain briefly the thought experiment famously known as 'Schrodinger cat'.

B4. The vector triple product $\vec{F}_1 \times (\vec{F}_2 \times \vec{F}_3)$ of three forces expressed in units of newton as

$\vec{F}_1 = 3x^2\hat{i} + 2xy\,\hat{j} + 5xz\,\hat{k}$,

$\vec{F}_2 = 3xy\,\hat{i} + 2y^2\,\hat{j} + 5yz\,\hat{k}$, and

$\vec{F}_3 = 3xz\hat{i} + 2yz\hat{j} + 5z\hat{k}$ is a conservative force.

Defend or refute

B5. Every vector G (h k l) of the reciprocal lattice is normal to the set of lattice planes of the crystal lattice. Defend or refute.

B6. The X ray spectra of elements of nearby equal atomic numbers have been observed qualitatively similar while the optical spectra of these elements differ considerably. Defend or refute.

B7. The atoms in solids possess a certain zero-point energy even at 0 K while no such restriction is observed for the molecules in an ideal gas. Explain why? You may think on the basis of uncertainty principle.

B8. The elements with even number of electrons in their atoms exhibit normal Zeeman Effect. Defend or refute.

B9. The properties of liquid helium ${}_2He^4$ are quite different from those of ${}_2He^3$. Explain briefly and justify

B10. Given that the electric field $\vec{E} = \hat{k}\,E_0 \cos\omega\,(t - \frac{y}{c})$ and the magnetic field $\vec{B} = \hat{i}\,B_0 \cos\omega\,(t - \frac{y}{c})$ constitute a real electromagnetic field. Defend or refute.

Part B2 — 10 x 10 = 100

Solve all Ten Problems

P1. Given that $\vec{F} = \frac{1}{\pi}[\hat{i}\sin(-y) + \hat{j}\,x(1-\cos y)]$ is a vector. Find the value of the line integral $\oint_c \vec{F}.d\vec{r}$ along the circle c given by $x^2 + y^2 = 1$ evaluated in anticlockwise direction.

P2. The applied voltage phasor in an AC circuit is V = (4 + 3j) volt and the resulting current phasor is i = (3 + 4j) ampere. Draw phasor diagram. Determine the impedance (Z) of the circuit and indicate whether the impedance is inductive or capacitive? Also calculate the power dissipated in the circuit. Note that the phasor $j = \sqrt{-1}$

P3. When excited by a light of wavelength λ = 4358Å, a transparent substance produces a Stoke Raman frequency shift of 458 cm^{-1} Calculate the wavelength of the corresponding anti Stoke line.

P4. A certain spectral line of wavelength λ is observed at θ=10° in the second order diffraction spectrum produced by a plane transmission diffraction grating. Another spectral line with a wavelength greater by 0.5×10^{-10}m than λ appears at 10°0′3″. Find the value of wavelength λ and the minimum grating width (ruled space) to resolve the two lines in the second order.

P5. An ideal diatomic gas is examined under two thermodynamic process namely the

Process 1: Isothermal expansion from volume V_1 to V_0 to V_2 with corresponding pressure as P_{T1} to P_0 to P_{T2} and the work done by the gas from (P_{T1}, V_1) to (P_0, V_0) is W_{T1} while the work done from (P_0, V_0) to (P_{T2}, V_2) is W_{T2}

Process 2: Adiabatic expansion from volume V_1 to V_0 to V_2 with corresponding pressure as P_{S1} to P_0 to P_{S2} and the work done by the gas from (P_{S1}, V_1) to (P_0, V_0) is W_{S1} while the work done from (P_0, V_0) to (P_{S2}, V_2) is W_{S2}

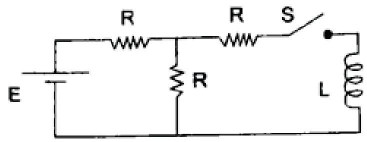
(a) Depict the two processes neatly on a P-V diagram on your copy and explain the difference between the two cases.

(b) How does the work W_{T1} compares W_{S1} and the work W_{T2} compares W_{S2}

(c) Compare the slope of the curve at $(P_0 V_0)$ in the two cases

(d) In which case the change in entropy is more and how much?

P6. A DC circuit consists of a source of emf E, three resistances each equal to R and an inductance L as shown in the figure. The switch S is closed at a certain time t = 0 (say).



Analyse the circuit to evaluate

(a) The current drawn from the battery at t = 0 when the switch is just closed.

(b) The saturation current through the inductor when the switch has been closed for a long time.

(c) The instantaneous current through the inductance L at any time t after closing the switch. Express all your results in term of known parameters E, R and L and the time t.

P7. The density of zinc $(1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2)$ is $\rho = 7130\ kgm^{-3}$ and its atomic weight is A = 65.4 Calculate the Fermi energy (E_F) of zinc. Given that the effective mass of free electron in zinc crystal is $m^* = 7.7 \times 10^{-31}$ kg and the value of Avogadro's number is $N = 6.023 \times 10^{23}$ atoms per gram-atom.

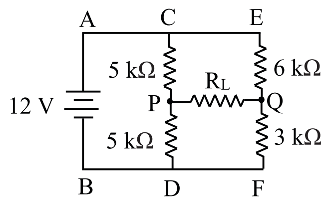
P8. The normalized wave function Ψ_1 and Ψ_2 correspond to the ground state and the first excited state of a particle in a certain potential field. An operator $\hat{A}$ operates on the two functions as $\hat{A}\Psi_1 = \Psi_2$ and $\hat{A}\Psi_2 = \Psi_1$. Find the expectation value of the operator $\hat{A}$ for the state $\Psi = \dfrac{3\Psi_1 + 4\Psi_2}{5}$ Also show that the wave functions Ψ_1 and Ψ_2 are the eigen functions of A^2.

P9. In a nuclear reactor, the radio-nuclide of half-life 1650 sec is being produced at a constant rate of 1000 nuclides per second. During each decay an energy of 200 MeV is produced. Let the production of radio nuclei starts at t = 0. Estimate

(a) The rate of release of energy at t = 3240 sec

(b) The total energy produced in 405 sec

P10. An electric network containing a source of emf and impedances is shown in figure.



(a) Obtain a Thevenin equivalent circuit for the network.

(b) Using the Thevenin equivalent circuit, calculate current passing through the load R_L when $R_L = 500\ \Omega$

(c) Convert the Thevenin equivalent circuit so obtained into its Norton equivalent circuit