PhysicsByAaryan

CSIR NET · GATE · JEST · BARC – Physics

GATE Physics 2024 — Full Question Paper

Previous Year Questions with Official Answer Key

Inside this PDF

- Every GATE Physics (PH) 2024 question, in order
- Marking scheme + question type (MCQ/MSQ/NAT) on every question
- Subject & topic classification per question
- Official answer key at the end

65 Questions with answer key

Questions taken from official GATE Physics (PH) papers conducted by IITs / IISc.
Compiled by PhysicsByAaryan for free use by aspirants. Answer key at the end of this PDF.

Q1. [Marks: 1 | MCQ] General Aptitude · English

Gate 2024	MCQ	1M

If ' → ' denotes increasing order of intensity, then the meaning of the words [smile ⟶ giggle → laugh] is analogous to [disapprove → ___ → chide]. Which one of the given options is appropriate to fill the blank?

(A) reprove

(B) praise

(C) reprise

(D) grieve

Q2. [Marks: 1 | MCQ] General Aptitude · Reasoning

Gate 2024	MCQ	1M

Find the odd one out in the set:

{19,37,21,17,23,29,31,11}

(A) 21

(B) 29

(C) 37

(D) 23

Q3. [Marks: 1 | MCQ] General Aptitude · Mathematical Analysis

Gate 2024	MCQ	1M

In the following series, identify the number that needs to be changed to form the Fibonacci series.

$$1,1,2,3,6,8,13,21, \ldots$$

(A) 8

(B) 21

(C) 6

(D) 13

Q4. [Marks: 1 | MCQ] General Aptitude · Mathematical Analysis

Gate 2024	MCQ	1M

The real variables x, y, z, and the real constants p, q, r satisfy

$$\frac{x}{pq - r^2} = \frac{y}{qr - p^2} = \frac{z}{rp - q^2}$$

Given that the denominators are non-zero, the value of $px + qy + rz$ is

(A) 0

(B) 1

(C) pqr

(D) $p^2 + q^2 + r^2$

Q5. [Marks: 1 | MCQ] General Aptitude · Mathematical Analysis

Gate 2024	MCQ	1M

Take two long dice (rectangular parallelepiped), each having four rectangular faces labelled as 2,3,5, and 7 . If thrown, the long dice cannot land on the square faces and has 1/4 probability of landing on any of the four rectangular faces. The label on the top face of the dice is the score of the throw.
If thrown together, what is the probability of getting the sum of the two long dice scores greater than 11?

(A) 3/8
(B) 1/8
(C) 1/16
(D) 3/16

Q6. [Marks: 2 | MCQ] General Aptitude · English

Gate 2024	MCQ	2 M

In the given text, the blanks are numbered (i)-(iv). Select the best match for all the blanks.

Prof. P ___ (i) merely a man who narrated funny stories. ___ (ii) in his blackest moments he was capable of self-deprecating humor.

Prof. Q ___ (iii) a man who hardly narrated funny stories. ___ (iv) in his blackest moments was he able to find humor.

(A) (i) was (ii) Only (iii) wasn't (iv) Even

(B) (i) wasn't (ii) Even (iii) was (iv) Only

(C) (i) was (ii) Even (iii) wasn't (iv) Only

(D) (i) wasn't (ii) Only (iii) was (iv) Even

Q7. [Marks: 2 | MCQ] General Aptitude · Mathematical Analysis

Gate 2024	MCQ	2 M

How many combinations of non-null sets A , B , C are possible from the subsets of $\{2,3,5\}$ satisfying the conditions: (i) A is a subset of B , and (ii) B is a subset of C ?

(A) 28

(B) 27

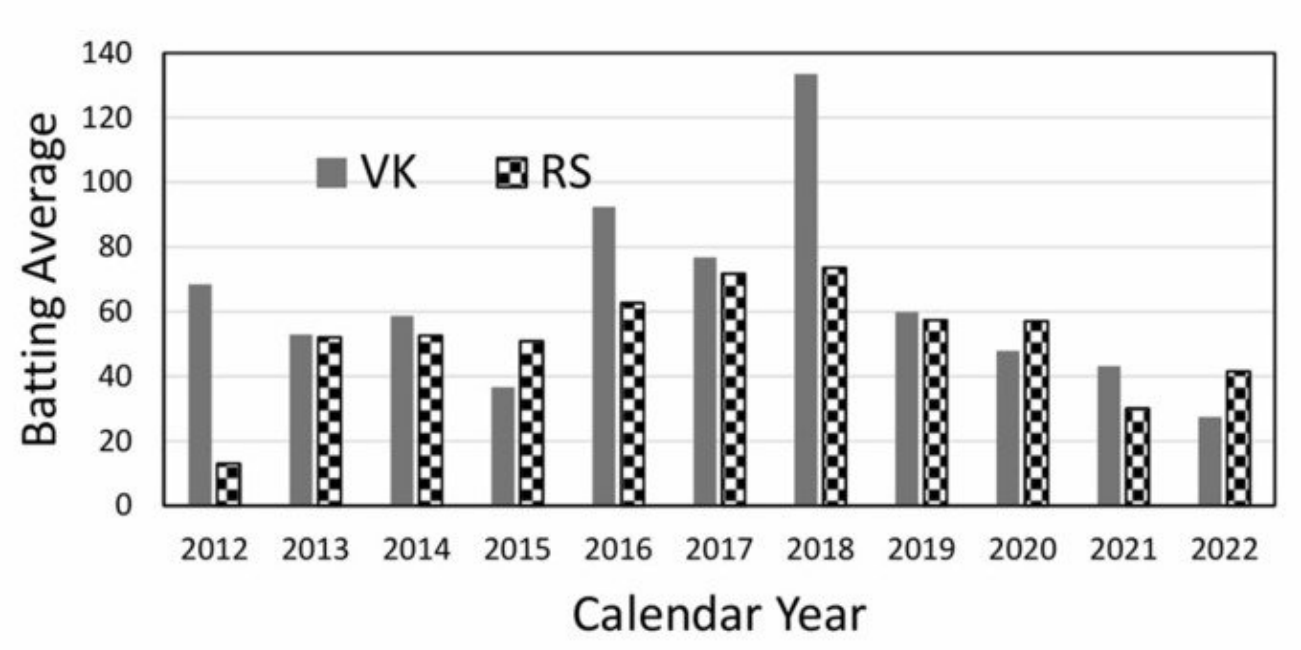
(C) 18

(D) 19

Q8. [Marks: 2 | MCQ] General Aptitude · Data Analysis

Gate 2024	MCQ	2 M

The bar chart gives the batting averages of VK and RS for 11 calendar years from 2012 to 2022. Considering that 2015 and 2019 are world cup years, which one of the following options is true?



(A) RS has a higher yearly batting average than that of VK in every world cup year.

(B) VK has a higher yearly batting average than that of RS in every world cup year.

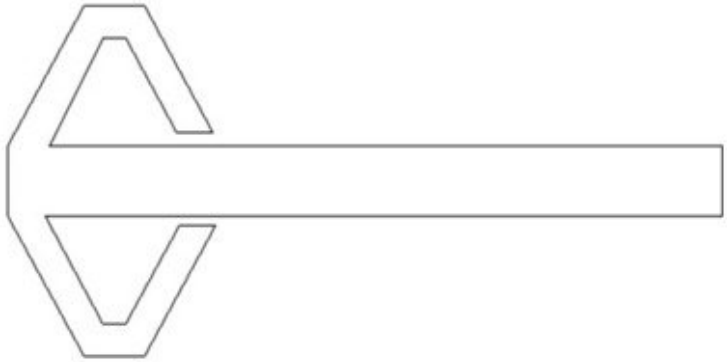
(C) VK's yearly batting average is consistently higher than that of RS between the two world cup years.

(D) RS's yearly batting average is consistently higher than that of VK in the last three years.

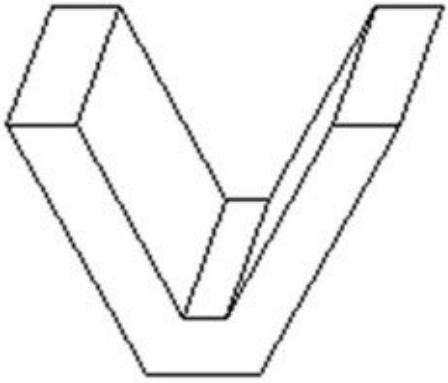
Q9. [Marks: 2 | MCQ] General Aptitude · Reasoning

Gate 2024	MCQ	2 M

A planar rectangular paper has two V-shaped pieces attached as shown below.



This piece of paper is folded to make the following closed three-dimensional object.



The number of folds required to form the above object is

(A) 9

(B) 7

(C) 11

(D) 8

Q10. [Marks: 2 | MCQ] General Aptitude · Geometry

Gate 2024	MCQ	2 M

Four equilateral triangles are used to form a regular closed three-dimensional object by joining along the edges. The angle between any two faces is

(A) 30°

(B) 60°

(C) 45°

(D) 90°

Q11. [Marks: 1 | MCQ] Classical Mechanics · Canonical Transformation and Poisson bracket

Gate 2024	MCQ	1 M

If $F_1(Q, q) = Qq$ is the generating function of a canonical transformation from (p, q) to (P, Q), then which one of the following relations is correct?

(A) $\frac{p}{P} = \frac{Q}{q}$

(B) $\frac{P}{p} = \frac{Q}{q}$

(C) $\frac{p}{P} = -\frac{Q}{q}$

(D) $\frac{P}{p} = -\frac{Q}{q}$

Q12. [Marks: 1 | MCQ] Optics · Polarization

Gate 2024	MCQ	1 M

An unpolarized plane electromagnetic wave in a dielectric medium 1 is incident on a plane interface that separates medium 1 from another dielectric medium 2. Medium 1 and medium 2 have refractive indices n_1 and n_2, respectively, with $n_2 > n_1$. If the angle of incidence is $\tan^{-1}\left(\frac{n_2}{n_1}\right)$, which one of the following statements is true?

(A) The reflected wave is unpolarized

(B) The reflected wave is polarized parallel to the plane of incidence

(C) The reflected wave is polarized perpendicular to the plane of incidence

(D) There is no transmitted wave

Q13. [Marks: 1 | MCQ] Quantum Mechanics · Basics Quantum Mechanics

Gate 2024	MCQ	1 M

The wavefunction of a particle in an infinite one-dimensional potential well at time t is

$$\Psi(x,t) = \sqrt{\frac{2}{3}}e^{-iE_1t/\hbar}\psi_1(x) + \frac{1}{\sqrt{6}}e^{i\pi/6}e^{-iE_2t/\hbar}\psi_2(x) + \frac{1}{\sqrt{6}}e^{i\pi/4}e^{-iE_3t/\hbar}\psi_3(x)$$

where ψ_1, ψ_2 and ψ_3 are the normalized ground state, the normalized first excited state and the normalized second excited state, respectively. E_1, E_2 and E_3 are the eigen-energies corresponding to ψ_1, ψ_2 and ψ_3, respectively. The expectation value of energy of the particle in state $\Psi(x,t)$ is

(A) $\frac{17}{6}E_1$

(B) $\frac{2}{3}E_1$

(C) $\frac{3}{2}E_1$

(D) $14E_1$

Q14. [Marks: 1 | MCQ] Thermodynamics · Thermodynamic Potential

Gate 2024	MCQ	1 M

If a thermodynamical system is adiabatically isolated and experiences a change in volume under an externally applied constant pressure, then the thermodynamical potential minimized at equilibrium is the

(A) enthalpy

(B) Helmholtz free energy

(C) Gibbs free energy

(D) grand potential

Q15. [Marks: 1 | MCQ] Atomic and Molecular Physics · Molecular Physics

Gate 2024	MCQ	1 M

The mean distance between the two atoms of HD molecule is r, where H and D denote hydrogen and deuterium, respectively. The mass of the hydrogen atom is m_H. The energy difference between two lowest lying rotational states of HD in multiples of $\hbar^2/(m_H r^2)$ is

(A) $\frac{3}{2}$

(B) $\frac{2}{3}$

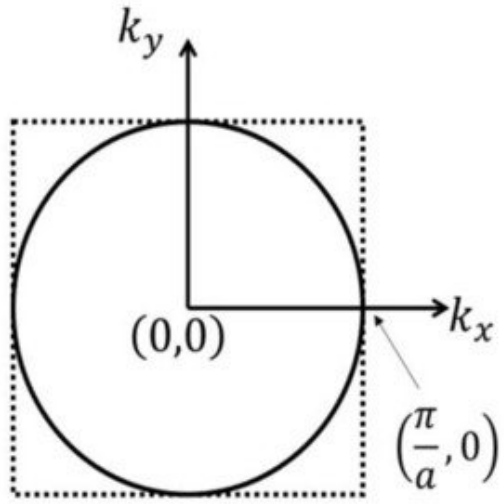
(C) 6

(D) $\frac{4}{3}$

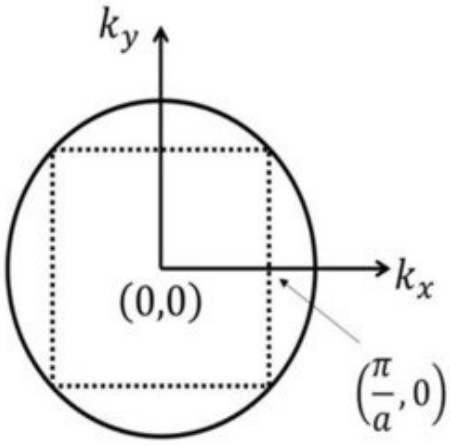
Q16. [Marks: 1 | MCQ] Solid State Physics · Free electron model

Gate 2024	MCQ	1 M

Crystal structures of two metals A and B are two-dimensional square lattices with same lattice constant a. Electrons in metals behave as free electrons. The Fermi surfaces corresponding to A and B are shown by solid circles in figures.



Metal A



Metal B

The electron concentrations in A and B are n_A and n_B, respectively. The value of $\left(\frac{n_B}{n_A}\right)$ is

(A) 3

(B) 2

(C) $3\sqrt{3}$

(D) $\sqrt{2}$

Q17. [Marks: 1 | MCQ] Nuclear and Particle Physics · Radioactivity

Gate 2024	MCQ	1 M

Consider the induced nuclear fission reaction

$$^{235}_{92}U + n \rightarrow {}^{93}_{37}Rb + {}^{141}_{55}Cs + 2n$$

where neutron momenta in both initial and final states are negligible. The ratio of the kinetic energies (KE) of the daughter nuclei,

$$\frac{\mathrm{KE}(^{93}_{37}\mathrm{Rb})}{\mathrm{KE}(^{141}_{55}\mathrm{Cs})}$$

is ____

(A) $\frac{93}{141}$

(B) $\frac{141}{93}$

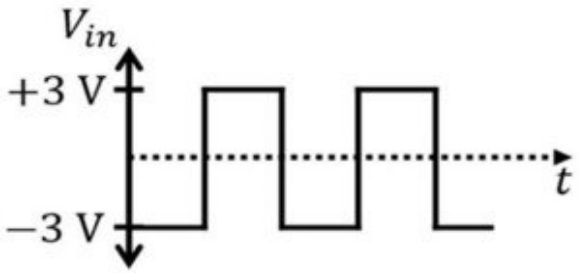
(C) 1

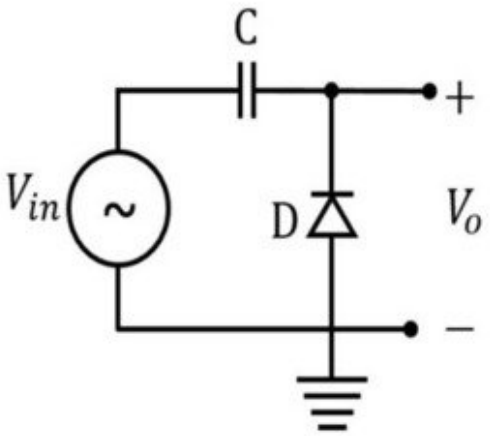
(D) 0

Q18. [Marks: 1 | MCQ] Electronics · Diodes

Gate 2024	MCQ	1 M

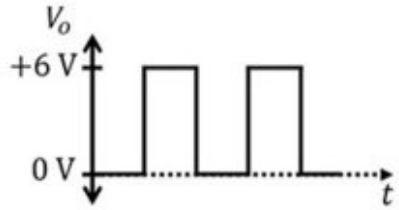
The symbols C, D, V_{in} and V_0 shown in the figure denote capacitor, ideal diode, input voltage and output voltage, respectively.



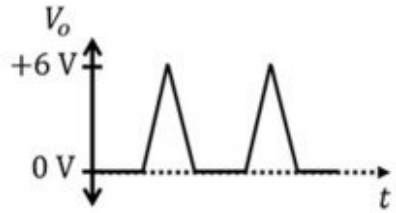


Which one of the following output waveforms (V_0) is correct for the given input waveform (V_{in})?

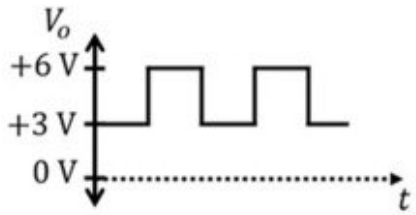
(A)



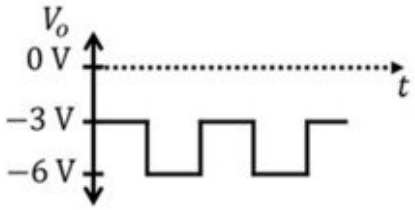
(B)



(C)



(D)

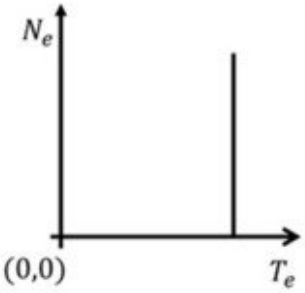


Q19. [Marks: 1 | MCQ] Nuclear and Particle Physics · Radioactivity

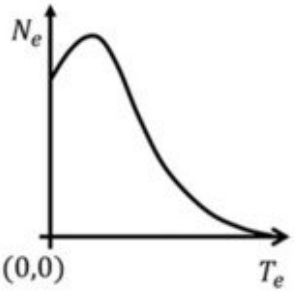
Gate 2024	MCQ	1 M

Let N_e and T_e, respectively, denote number and kinetic energy of electrons produced in a nuclear beta decay. Which one of the following distributions is correct?

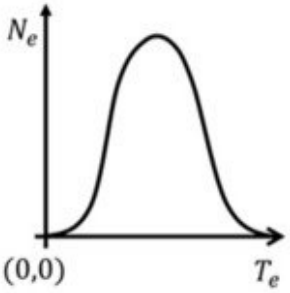
(A)



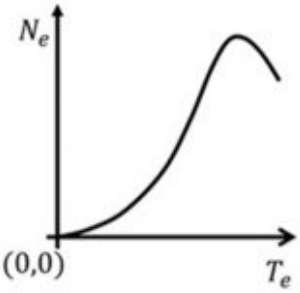
(C)



(B)



(D)



Q20. [Marks: 1 | MCQ] Electromagnetism · Magnetism in matter

Gate 2024	MCQ	1 M

An infinitely long cylinder of radius R carries a frozen-in magnetization $\vec{M} = ke^{-s}\hat{z}$, where k is a constant and s is the distance from the axis of cylinder. The magnetic permeability of free space is μ_0. There is no free current present anywhere. The magnetic flux density ($\vec{B}$) inside the cylinder is

(A) 0

(B) $\mu_0 ke^{-R}\hat{z}$

(C) $\mu_0 ke^{-s}\hat{z}$

(D) $\mu_0 ke^{-s}\left(\frac{R}{s}\right)\hat{z}$

Q21. [Marks: 1 | MCQ] Atomic and Molecular Physics · ESR/EPR/NMR

Gate 2024	MCQ	1 M

Atomic numbers of V, Cr, Fe and Zn are 23,24,26 and 30 , respectively. Which one of the following materials does NOT show an electron spin resonance (ESR) spectra?

(A) V

(B) Cr

(C) Fe

(D) Zn

Q22. [Marks: 1 | MCQ] Quantum Mechanics · Potential Well

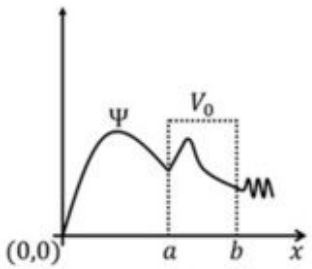
Gate 2024	MCQ	1 M

A particle is subjected to a potential

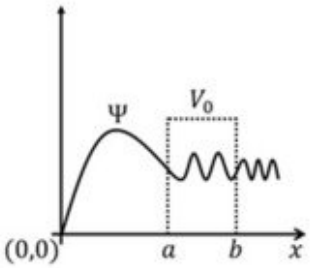
$$V(x) = \begin{cases} \infty, & x \leq 0 \\ V_0, & a \leq x \leq b \\ 0, & \text{elsewhere} \end{cases}$$

Here, $a > 0$ and $b > a$. If the energy of the particle $E < V_0$, which one of the following schematics is a valid quantum mechanical wavefunction (Ψ) for the system?

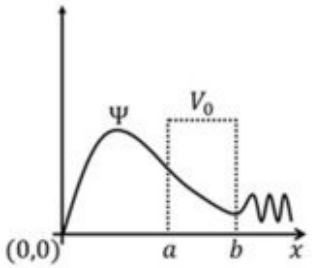
(A)



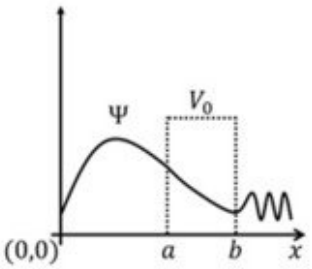
(C)



(B)



(D)



Q23. [Marks: 1 | MCQ] Classical Mechanics · Canonical Transformation and Poisson bracket

Gate 2024	MCQ	1 M

Let $\rho(\vec{p}, \vec{q}, t)$ be the phase space density of an ensemble of a system. The Hamiltonian of the system is $H(\vec{p}, \vec{q})$. If $\{A, B\}$ denotes the Poisson bracket of A and B, then

$$\frac{d\rho}{dt} = 0$$

implies

(A) $\frac{\partial \rho}{\partial t} = 0$

(B) $\frac{\partial \rho}{\partial t} \propto \{\rho, H\}$

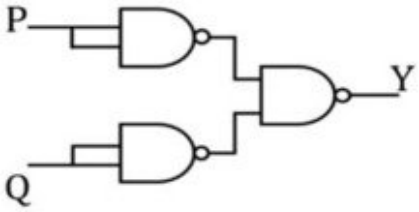
(C) $\frac{\partial \rho}{\partial t} \propto \left\{\rho, \frac{\vec{p}\cdot\vec{q}}{2}\right\}$

(D) $\frac{\partial \rho}{\partial t} \propto \left\{\rho, \frac{\vec{q}\cdot\vec{q}}{2}\right\}$

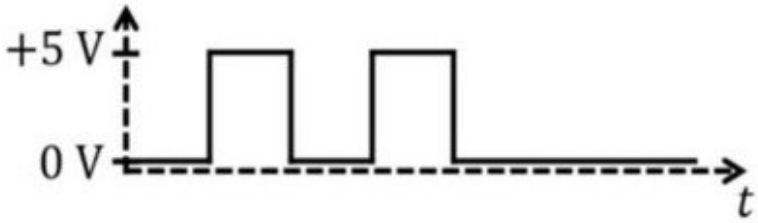
Q24. [Marks: 1 | MCQ] Electronics · Logic Gates

Gate 2024	MCQ	1 M

Consider the following circuit:



Suppose the input signal P is



And the input signal Q is

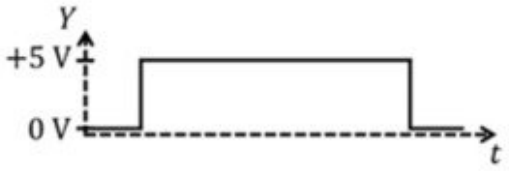
Which one of the following output signal is correct?

(A)

(B)

(C)

(D)



Q25. [Marks: 1 | MCQ] Classical Mechanics · Special theory of relativity

Gate 2024	MCQ	1 M

An inertial observer sees two spacecrafts S and T flying away from each other along x-axis with individual speed $0.5c$, where c is the speed of light. The speed of T with respect to S is

(A) $\frac{4}{5}c$

(B) $\frac{4}{3}c$

(C) c

(D) $\frac{2}{3}c$

Q26. [Marks: 1 | MCQ] Nuclear and Particle Physics · Particle Physics

Gate 2024	MCQ	1 M

Let P, Q and R be three different nuclei. Which one of the following nuclear processes is possible?

(A) $v_e + {}^{A}_{Z}P \rightarrow {}^{A}_{Z+1}Q + e^-$

(B) $v_e + {}^{A}_{Z}P \rightarrow {}^{A}_{Z-1}R + e^+$

(C) $v_e + {}^{A}_{Z}P \rightarrow {}^{A}_{Z}P + e^+ + e^-$

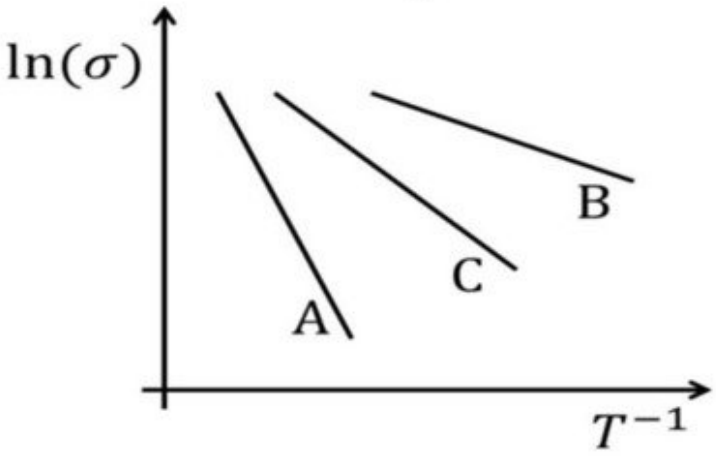
(D) $v_e + {}^{A}_{Z}P \rightarrow {}^{A}_{Z}P + \gamma$

Q27. [Marks: 1 | MCQ] Solid State Physics · Superconductivity

Gate 2024	MCQ	1 M

The temperature dependence of the electrical conductivity (σ) of three intrinsic semiconductors A, B and C is shown in figure.

Let E_A, E_B and E_C be the bandgaps of A, B and C, respectively. Which one of the following relations is correct?



(A) $E_C > E_A > E_B$

(B) $E_B > E_C > E_A$

(C) $E_A > E_B > E_C$

(D) $E_A > E_C > E_B$

Q28. [Marks: 1 | MCQ] Quantum Mechanics · Variational Principle

Gate 2024	MCQ	1 M

Following trial wavefunctions

$$\phi_1 = e^{-Z'(r_1+r_2)}$$

and

$$\phi_2 = e^{-Z'(r_1+r_2)}(1 + g|\vec{r}_1 - \vec{r}_2|)$$

are used to get a variational estimate of the ground state energy of the helium atom. Z' and g are the variational parameters, $\vec{r}_1$ and $\vec{r}_2$ are the position vectors of the electrons. Let E_0 be the exact ground state energy of the helium atom. E_1 and E_2 are the variational estimates of the ground state energy of the helium atom corresponding to ϕ_1 and ϕ_2, respectively. Which one of the following options is true?

(A) $E_1 \leq E_0, E_2 \leq E_0, E_1 \geq E_2$

(B) $E_1 \geq E_0, E_2 \leq E_0, E_1 \geq E_2$

(C) $E_1 \leq E_0, E_2 \geq E_0, E_1 \leq E_2$

(D) $E_1 \geq E_0, E_2 \geq E_0, E_1 \geq E_2$

Q29. [Marks: 1 | MCQ] Quantum Mechanics · Basics Quantum Mechanics

Gate 2024	MCQ	1 M

The wavefunction for a particle is given by the form $e^{-(i\alpha x+\beta)}$, where α and β are real constants. In which one of the following potentials $V(x)$, the particle is moving?

(A) $V(x) \propto \alpha^2 x^2$

(B) $V(x) \propto e^{-\alpha x}$

(C) $V(x) = 0$

(D) $V(x) \propto \sin(\alpha x)$

Q30. [Marks: 1 | MSQ] Mathematical Physics · Vector Analysis

Gate 2024	MSQ	1 M

Consider a volume integral

$$I = \int_V \nabla^2 \left(\frac{1}{r}\right) dV$$

over a volume V, where $r = \sqrt{x^2 + y^2 + z^2}$. Which of the following statement is/are correct?

(A) $I = -4\pi$, if $r = 0$ is inside the volume V

(B) Integrand vanishes for $r \neq 0$

(C) $I = 0$, if $r = 0$ is not inside the volume V

(D) Integrand diverges as $r \to \infty$

Q31. [Marks: 1 | MSQ] Mathematical Physics · Complex Analysis

Gate 2024	MSQ	1 M

The complex function

$$e^{-\left(\frac{2}{z-1}\right)}$$

has ___

(A) a simple pole at $z = 1$

(B) an essential singularity at $z = 1$

(C) a residue equal to -2 at $z = 1$

(D) a branch point at $z = 1$

Q32. [Marks: 1 | NAT] Electronics · Logic Gates

Gate 2024	NAT	1 M

The minimum number of basic logic gates required to realize the Boolean expression $B \cdot (A + B) + A \cdot (\bar{B} + A)$ is ___ (in integer).

Q33. [Marks: 1 | NAT] Thermodynamics · Phase transition

Gate 2024	NAT	1 M

The vapor pressure (P) of solid ammonia is given by $\ln(P) = 23.03 - \frac{3754}{T}$, while that of liquid ammonia is given by $\ln(P) = 19.49 - \frac{3063}{T}$, where T is the temperature in K.

The temperature of the triple point of ammonia is ___ K (rounded off to two decimal places).

Q34. [Marks: 1 | NAT] Electromagnetism · Electrostatics

Gate 2024	NAT	1 M

The electric field in a region depends only on x and y coordinates as

$$\vec{E} = k\frac{(x\hat{x} + y\hat{y})}{x^2 + y^2}$$

where k is a constant. The flux of $\vec{E}$ through the surface of a sphere of radius R with its center at the origin is $n\pi kR$, where the value of n is ___ (in integer).

Q35. [Marks: 1 | NAT] Thermodynamics · Kinetic theory of gases

Gate 2024	NAT	1 M

The Hamiltonian of a system of N particles in volume V at temperature T is

$$H = \sum_{i=1}^{2N} a_i q_i^2 + \sum_{i=1}^{2N} b_i p_i^2$$

where a_i and b_i are positive constants. The ensemble average of the Hamiltonian is $\alpha N k_B T$, where k_B is the Boltzmann constant. The value of α is ___ (in integer).

Q36. [Marks: 2 | MCQ] Nuclear and Particle Physics · Nuclear properties

Gate 2024	MCQ	2 M

Binding energy and rest mass energy of a two-nucleon bound state are denoted by B and mc^2, respectively, where c is the speed of light. The minimum energy of a photon required to dissociate the bound state is

(A) B

(B) $B\left(1+\frac{B}{2mc^2}\right)$

(C) $B\left(1-\frac{B}{2mc^2}\right)$

(D) $B-mc^2$

Q37. [Marks: 2 | MCQ] Atomic and Molecular Physics · Effects in atomic physics

Gate 2024	MCQ	2 M

The spin-orbit interaction in a hydrogen-like atom is given by the Hamiltonian

$$H' = -k\vec{L} \cdot \vec{S}$$

where k is a real constant. The splitting between levels $^2p_{3/2}$ and $^2p_{1/2}$ due to this interaction is

(A) $\frac{1}{2}k\hbar^2$

(B) $\frac{3}{2}k\hbar^2$

(C) $\frac{3}{4}k\hbar^2$

(D) $2k\hbar^2$

Q38. [Marks: 2 | MCQ] Classical Mechanics · Lagrangian and Hamiltonian

Gate 2024	MCQ	2 M

Consider the Lagrangian $L = m\dot{x}\dot{y} - m\omega_0^2 xy$. If p_x and p_y denote the generalized momenta conjugate to x and y, respectively, then the canonical equations of motion are

(A) $\dot{x} = \frac{p_x}{m}, \dot{p}_x = -m\omega_0^2 x, \dot{y} = \frac{p_y}{m}, \dot{p}_y = -m\omega_0^2 y$

(B) $\dot{x} = \frac{p_x}{m}, \dot{p}_x = m\omega_0^2 x, \dot{y} = \frac{p_y}{m}, \dot{p}_y = m\omega_0^2 y$

(C) $\dot{x} = \frac{p_y}{m}, \dot{p}_x = -m\omega_0^2 y, \dot{y} = \frac{p_x}{m}, \dot{p}_y = -m\omega_0^2 x$

(D) $\dot{x} = \frac{p_y}{m}, \dot{p}_x = m\omega_0^2 y, \dot{y} = \frac{p_x}{m}, \dot{p}_y = m\omega_0^2 x$

Q39. [Marks: 2 | MCQ] Solid State Physics · Xray diffraction

Gate 2024	MCQ	2 M

The X-ray diffraction pattern of a monatomic cubic crystal with rigid spherical atoms of radius 1.56 Å shows several Bragg reflections of which the reflection appearing at the lowest 2θ value is from (111) plane. If the wavelength of X-ray used is 0.78Å, the Bragg angle (in 2θ, rounded off to one decimal place) corresponding to this reflection and the crystal structure, respectively, are

(A) 21.6° and body centered cubic

(B) 17.6° and face centered cubic

(C) 10.8° and body centered cubic

(D) 8.8° and face centered cubic

Q40. [Marks: 2 | MCQ] Electromagnetism · Electrostatics

Gate 2024	MCQ	2 M

In a parallel plate capacitor, the plate at $x = 0$ is grounded and the plate at $x = d$ is maintained at a potential V_0. The space between the two plates is filled with a linear dielectric of permittivity $\epsilon = \epsilon_0 \left(1 + \frac{x}{d}\right)$, where ϵ_0 is the permittivity of free space. Neglecting the edge effects, the electric field($\vec{E}$) inside the capacitor is

(A) $-\frac{V_0}{(d+x)\ln 2}\hat{x}$

(B) $-\frac{V_0}{d}\hat{x}$

(C) $-\frac{V_0}{(d+x)}\hat{x}$

(D) $-\frac{V_0 d}{(d+x)x}\hat{x}$

Q41. [Marks: 2 | MCQ] Classical Mechanics · Small Oscillations

Gate 2024	MCQ	2 M

The equation of motion for the forced simple harmonic oscillator is

$$\ddot{x}(t) + \omega^2 x(t) = F\cos(\omega t)$$

where $x(t=0) = 0$ and $\dot{x}(t=0) = 0$. Which one of the following options is correct?

(A) $x(t) \propto t\sin(\omega t)$

(B) $x(t) \propto t\cos(\omega t)$

(C) $x(t) = \infty$

(D) $x(t) \propto e^{\omega t}$

Q42. [Marks: 2 | MCQ] Atomic and Molecular Physics · Effects in atomic physics

Gate 2024	MCQ	2 M

An atom is subjected to a weak uniform magnetic field $\vec{B}$. The number of lines in its Zeeman spectrum for transition from $n = 2, l = 1$ to $n = 1, l = 0$ is

(A) 8

(B) 10

(C) 12

(D) 5

Q43. [Marks: 2 | MSQ] Mathematical Physics · Matrices

Gate 2024	MSQ	2 M

Consider two matrices: $P = \begin{bmatrix} 1 & 2 \\ 0 & 1 \end{bmatrix}$ and $Q = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$.

Which of the following statement is/are true?

(A) P and Q have same set of eigenvalues

(B) P and Q commute with each other

(C) P and Q have different sets of linearly independent eigenvectors

(D) P is diagonalizable

Q44. [Marks: 2 | MSQ] Solid State Physics · Magnetic properties of solids

Gate 2024	MSQ	2 M

An infinite one dimensional lattice extends along x-axis. At each lattice site there exists an ion with spin $\frac{1}{2}$. The spin can point either in $+z$ or $-z$ direction only. Let S_P, S_F, and S_A denote the entropies of paramagnetic, ferromagnetic and antiferromagnetic configurations, respectively. Which of the following relation is/are true?

(A) $S_P > S_F$

(B) $S_A > S_F$

(C) $S_A = 4\,S_F$

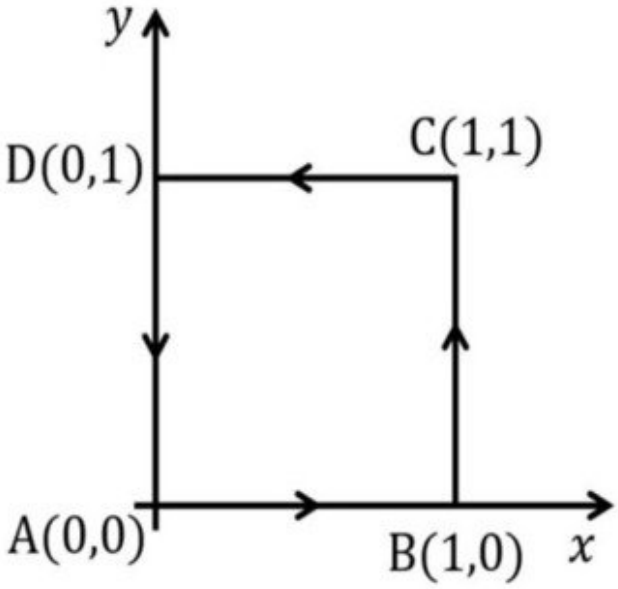
(D) $S_P > S_A$

Q45. [Marks: 2 | MSQ] Mathematical Physics · Vector Analysis

Gate 2024	MSQ	2 M

Consider a vector field $\vec{F} = (2xz + 3y^2)\hat{y} + 4yz^2\hat{z}$. The closed path ($\Gamma: A \to B \to C \to D \to A$) in $z = 0$ plane is shown in figure.

$\oint_{\Gamma} \vec{F}.\overrightarrow{dl}$ denotes the line integral of $\vec{F}$ along the closed path Γ. Which of the following option is/are true?



(A) $\oint_{\Gamma} \vec{F} \cdot \overrightarrow{dl} = 0$

(B) $\vec{F}$ is non-conservative

(C) $\vec{\nabla} \cdot \vec{F} = 0$

(D) $\vec{F}$ can be written as the gradient of a scalar field

Q46. [Marks: 2 | MSQ] Electromagnetism · Image Problem

Gate 2024	MSQ	2 M

Two point charges of charge $+q$ each are placed a distance $2d$ apart. A grounded solid conducting sphere of radius a is placed midway between them. Assume $a^2 \ll d^2$. Which of the following statement is/are true?

(A) If $a > \frac{d}{8}$, the net force acting on the charges is directed towards each other

(B) The potential at the surface of the sphere is zero

(C) Total induced charge on the sphere is $\left(-\frac{2aq}{d}\right)$

(D) The potential at the center of the sphere is non-zero

Q47. [Marks: 2 | MSQ] Quantum Mechanics · Quantum Harmonic Oscillator

Gate 2024	MSQ	2 M

A particle of mass m is moving in the potential

$$V(x) = \begin{cases} V_0 + \frac{1}{2}m\omega_0^2 x^2, & x > 0 \\ \infty, & x \leq 0 \end{cases}$$

Figures P, Q, R and S show different combinations of the values of ω_0 and V_0.

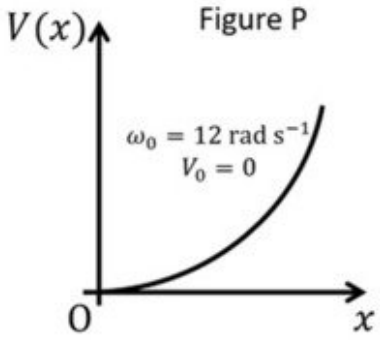
$E_j^{(P)}, E_j^{(Q)}, E_j^{(R)}$ and $E_j^{(S)}$ with $j = 0,1,2, \ldots$, are the eigen-energies of the j-th level for the potentials shown in figures P, Q, R and S , respectively. Which of the statement is/are true?

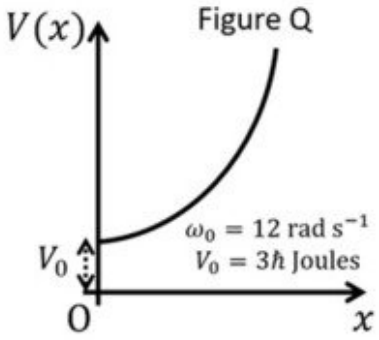
(A) $E_0^{(P)} = E_0^{(Q)}$

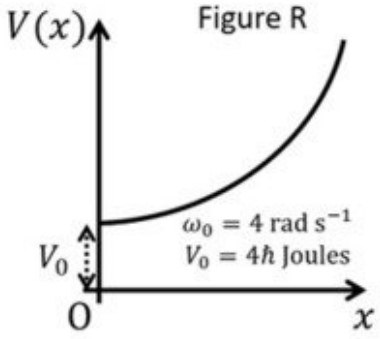
(B) $E_0^{(Q)} = E_0^{(S)}$

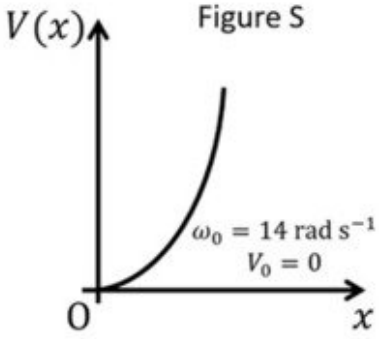
(C) $E_0^{(P)} = E_1^{(R)}$

(D) $E_0^{(R)} \neq E_0^{(Q)}$









Q48. [Marks: 2 | MSQ] Quantum Mechanics · Spin and Total Angular momentum

Gate 2024	MSQ	2 M

The non-relativistic Hamiltonian for a single electron atom is

$$H_0 = \frac{p^2}{2m} - V(r)$$

where $V(r)$ is the Coulomb potential and m is the mass of the electron. Considering the spin-orbit interaction term

$$H' = \frac{1}{2m^2c^2}\frac{1}{r}\frac{dV}{dr}\vec{L}\cdot\vec{S}$$

added to H_0, which of the following statement is/are true?

(A) H' commutes with L^2

(B) H' commutes with L_z and S_z

(C) For a given value of principal quantum number n and orbital angular momentum quantum number l, there are $2(2l+1)$ degenerate eigenstates of H_0

(D) H_0, L^2, S^2, L_Z and S_Z have a set of simultaneous eigenstates

Q49. [Marks: 2 | MSQ] Nuclear and Particle Physics · Particle Physics

Gate 2024	MSQ	2 M

Decays of mesons and baryons can be categorized as weak, strong and electromagnetic decays depending upon the interactions involved in the processes. Which of the following option is/are true?

(A) $\pi^0 \rightarrow \gamma\gamma$ is a weak decay

(B) $\Lambda^0 \rightarrow \pi^0 + p$ is an electromagnetic decay

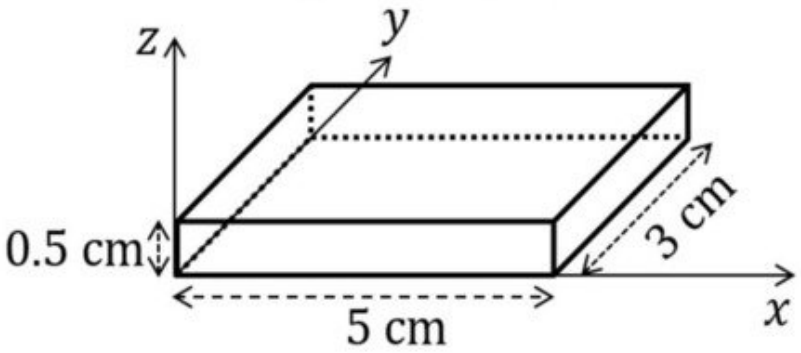
(C) $K^0 \rightarrow \pi^+ + \pi^-$ is a weak decay

(D) $\Delta^{++} \rightarrow p + \pi^+$ is a strong decay

Q50. [Marks: 2 | MSQ] Solid State Physics · Hall Effect

Gate 2024	MSQ	2 M

An extrinsic semiconductor shown in figure carries a current of 2 mA along its length parallel to $+x$ axis.



When the majority charge carrier concentration is $12.5 \times 10^{13}\ \mathrm{cm}^{-3}$ and the sample is exposed to a constant magnetic field applied along the $+z$ direction, a Hall voltage of 20 mV is measured with the negative polarity at $y = 0$ plane. Take the electric charge as $1.6 \times 10^{-19}\mathrm{C}$. The concentration of minority charge carrier is negligible. Which of the following statement is/are true?

(A) The majority charge carrier is electron

(B) The magnitude of the applied magnetic field is 1 Tesla

(C) The electric field corresponding to the Hall voltage is in the $+y$ direction

(D) The magnitude of Hall coefficient is $50{,}000\ \mathrm{m}^3\mathrm{C}^{-1}$

Q51. [Marks: 2 | MSQ] Mathematical Physics · Tensors

Gate 2024	MSQ	2 M

A^{α} and $B_{\beta}(\alpha, \beta = 1,2,3, \cdots, n)$ are contravariant and covariant vectors, respectively. By convention, any repeated indices are summed over. Which of the following expression is/are tensors?

(A) $A^{\alpha}B_{\beta}$

(B) $\frac{A^{\alpha}B_{\beta}}{A^{\alpha}B_{\alpha}}$

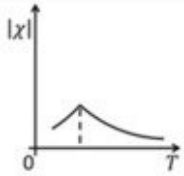
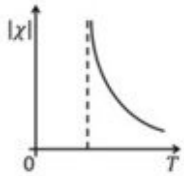
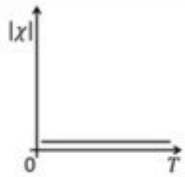
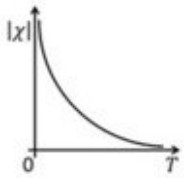
(C) $\frac{A^{\alpha}}{B_{\beta}}$

(D) $A^{\alpha} + B_{\beta}$

Q52. [Marks: 2 | MSQ] Solid State Physics · Magnetic properties of solids

Gate 2024	MSQ	2 M

The temperature T dependence of magnetic susceptibility χ (Column I) of certain magnetic materials (Column II) are given below. Which of the following option is/are correct?

Column I	Column II
(1) 	(P) Diamagnetic
(2) 	(Q) Paramagnetic
(3) 	(R) Ferromagnetic
(4) 	(S) Antiferromagnetic

(A) $2-\mathrm{P}, 4-\mathrm{Q}, 3-S$

(B) $4-\mathrm{P}, 1-\mathrm{Q}, 2-\mathrm{R}$

(C) $4-Q, 2-R, 1-S$

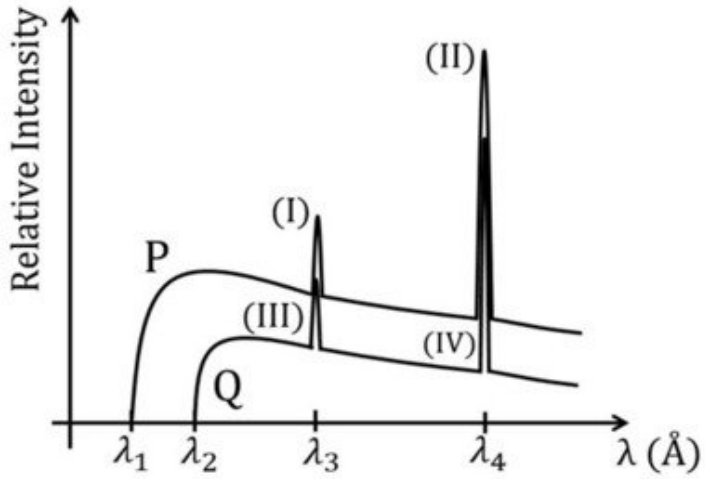
(D) $3-\mathrm{P}, 4-\mathrm{Q}, 2-\mathrm{R}$

Q53. [Marks: 2 | MSQ] Atomic and Molecular Physics · Xray spectra

Gate 2024	MSQ	2 M

The curves P and Q schematically show the variation of X-ray intensity with wavelength at two different accelerating voltages for a given target material.

In the figure $\lambda_1 = 0.25\text{Å}, \lambda_2 = 0.5\text{Å}, \lambda_3 = 1.0\text{Å}$, and $\lambda_4 = 2.25\text{Å}$. Take Planck's constant as $6.6 \times 10^{-34}\text{Js}$, speed of light as $3 \times 10^8\ \text{ms}^{-1}$ and elementary charge as $1.6 \times 10^{-19}\text{C}$.



Which of the following statement is/are true?

(A) The accelerating potential corresponding to curve P is greater than that of curve Q

(B) The accelerating potential applied to obtain curve Q is 24750 V

(C) Peaks (II) and (IV) correspond to radiative transitions from L to K shells

(D) Peaks (I) and (III) correspond to radiative transitions from N to K shells

Q54. [Marks: 2 | MSQ] Solid State Physics · Lattice vibration

Gate 2024	MSQ	2 M

Apart from the acoustic modes, 9 optical modes are identified from the measurements of phonon dispersions of a solid with chemical formula A_nB_m, where A and B denote the atomic species, and n and m are integers. Which of the following combination of n and m is/are possible?

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

(B) $n = 2, m = 2$

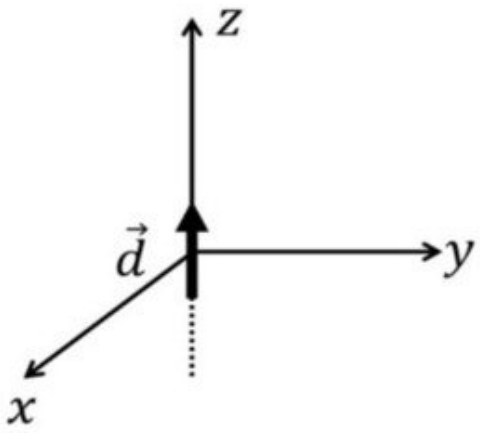
(C) $n = 3, m = 1$

(D) $n = 4, m = 4$

Q55. [Marks: 2 | MSQ] Electromagnetism · Radiations

Gate 2024	MSQ	2 M

An oscillating electric dipole of moment $\vec{d}(t) = d_0 \cos(\omega t)\hat{z}$ is placed at origin as shown in figure.



Consider a point $\mathrm{P}(r, \theta, \phi)$ at a very large distance from the dipole. Here r, θ and ϕ are spherical polar coordinates. Which of the following statement is/are true for intensity of radiation?

(A) Intensity is zero if P is on the z axis

(B) Intensity is zero at $\mathrm{P}\left(r = R, \theta = \frac{\pi}{2}, \phi = \frac{\pi}{4}\right)$

(C) Intensity at $\mathrm{P}\left(r = R, \theta = \frac{\pi}{2}, \phi = \frac{\pi}{4}\right)$ is greater than that at $\mathrm{P}\left(r = R, \theta = \frac{\pi}{4}, \phi = \frac{\pi}{4}\right)$

(D) Intensity at $\mathrm{P}\left(r = R, \theta = \frac{\pi}{2}, \phi = \frac{\pi}{4}\right)$ is equal to that at $\mathrm{P}\left(r = R, \theta = \frac{\pi}{4}, \phi = \frac{\pi}{4}\right)$

Q56. [Marks: 2 | MSQ] Mathematical Physics · Fourier and Laplace transform

Gate 2024	MSQ	2 M

The Fourier transform and its inverse transform are respectively defined as $\tilde{f}(\omega) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} f(x) e^{i\omega x} dx$ and $f(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} \tilde{f}(\omega) e^{-i\omega x} d\omega$. Consider two functions f and g. Another function $f * g$ is defined as

$$(f * g)(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{+\infty} f(y) g(x - y) dy$$

Which of the following relation is/are true?

Note: Tilde ($\sim$) denotes the Fourier transform.

(A) $f * g = g * f$

(B) $\widetilde{f * g} = \widetilde{g * f}$

(C) $\widetilde{f * g} = \tilde{f}\tilde{g}$

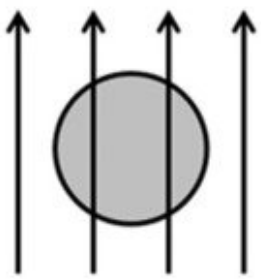
(D) $\widetilde{f * g} = \tilde{f}\tilde{g}$

Q57. [Marks: 2 | MSQ] Solid State Physics · Superconductivity

Gate 2024	MSQ	2 M

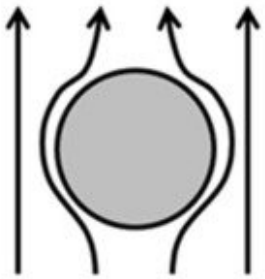
A material behaves as a superconductor below a critical temperature T_c and as a normal conductor above T_c. A magnetic field $\vec{B} = B\hat{z}$ is applied when $T > T_c$. The material is then cooled below T_c in the presence of $\vec{B}$. Which of the following figure represent the correct configuration of magnetic field lines?

(A)



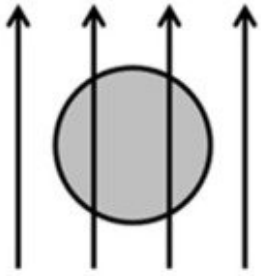
$T > T_C$

(C)



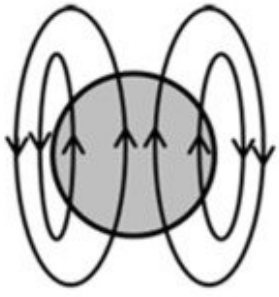
$T < T_C$

(B)



$T < T_C$

(D)

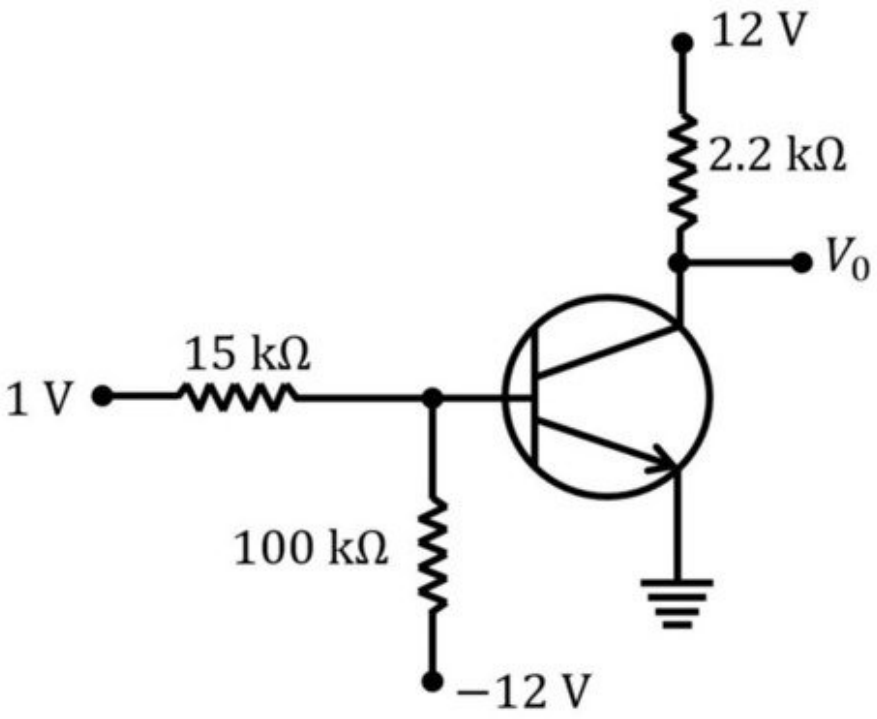


$T < T_C$

Q58. [Marks: 2 | NAT] Electronics · Transistors

Gate 2024	NAT	2 M

A typical biasing of a silicon transistor is shown in figure.



The value of common-emitter current gain β for the transistor is 100 . Ignore reverse saturation current. The output voltage V_0 (in V) is ___ (in integer).

Q59. [Marks: 2 | NAT] Statistical Mechanics · Canonical ensemble

Gate 2024	NAT	2 M

The canonical partition function of an ideal gas is

$$Q(T,V,N) = \frac{1}{N!}\left[\frac{V}{(\lambda(T))^3}\right]^N$$

where T, V, N and $\lambda(T)$ denote temperature, volume, number of particles, and thermal de Broglie wavelength, respectively. Let k_B be the Boltzmann constant and μ be the chemical potential. Take $\ln(N!) = N\ln(N) - N$.

If the number density $\left(\frac{N}{V}\right)$ is $2.5 \times 10^{25}\ \mathrm{m}^{-3}$ at a temperature T, then $\frac{e^{\mu/(k_B T)}}{(\lambda(T))^3} \times 10^{-25}$ is ____ m^{-3} (rounded off to one decimal place).

Q60. [Marks: 2 | NAT] Classical Mechanics · Lagrangian and Hamiltonian

Gate 2024	NAT	2 M

Lagrangian of a particle of mass m is $L = \frac{1}{2}m\dot{x}^2 - \lambda x^4$, where λ is a positive constant. If the particle oscillates with total energy E, then the time period of oscillations is

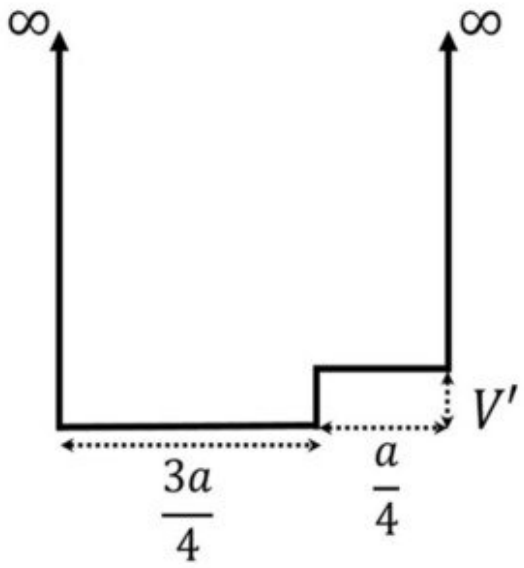
$$a\int_0^{\left(\frac{E}{\lambda}\right)^{\frac{1}{4}}} \frac{dx}{\sqrt{\left(\frac{2}{m}\right)(E-\lambda x^4)}}$$

The value of a is ___ (in integer).

Q61. [Marks: 2 | NAT] Quantum Mechanics · Perturbation Theory

Gate 2024	NAT	2 M

A particle of mass m in an infinite potential well of width a is subjected to a perturbation, $V' = \frac{h^2}{40ma^2}$ as shown in figure, where h is Planck's constant.



The first order energy shift of the fourth energy eigenstate due to this perturbation is

$$\left(\frac{h^2}{Nma^2}\right)$$

The value of N is ___ (in integer).

Q62. [Marks: 2 | NAT] Statistical Mechanics · Quantum Statistical Mechanics

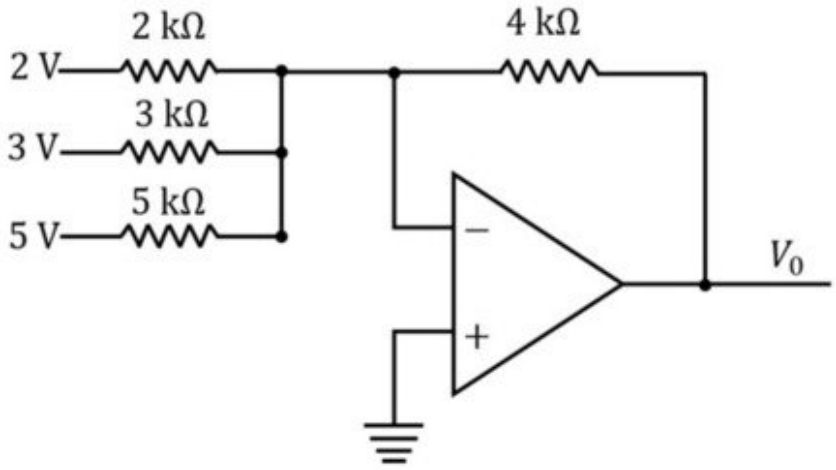
Gate 2024	NAT	2 M

Consider a three-dimensional system of non-interacting bosons with zero chemical potential. The energy of the system $\epsilon \propto k^2$, where k is the wavevector. The low temperature specific heat of the system at constant volume depends on the temperature as $C_V \propto T^{\frac{n}{2}}$. The value of n is ___ (in integer).

Q63. [Marks: 2 | NAT] Electronics · OPAMP

Gate 2024	NAT	2 M

Consider the operational amplifier circuit shown in figure.



The output voltage V_0 is ___ V (in integer).

Q64. [Marks: 2 | NAT] Quantum Mechanics · Orbital angular momentum and hydrogen atom

Gate 2024	NAT	2 M

An electron in the Coulomb field of a proton is in the following state of coherent superposition of orthonormal states ψ_{nlm}

$$\Psi = \frac{1}{3}\psi_{100} + \frac{1}{\sqrt{3}}\psi_{210} - \frac{\sqrt{5}}{3}\psi_{320}$$

Let E_1, E_2, and E_3 represent the first three energy levels of the system. A sequence of measurements is done on the same system at different times. Energy is measured first at time t_1 and the outcome is E_2. Then total angular momentum is measured at time $t_2 > t_1$ and finally energy is measured again at $t_3 > t_2$. The probability of finding the system in a state with energy E_2 after the final measurement is $P/9$. The value of P is ___ (in integer).

Q65. [Marks: 2 | NAT] Nuclear and Particle Physics · Shell Model

Gate 2024	NAT	2 M

According to the nuclear shell model, the absolute value of the difference in magnetic moments of $^{15}_{8}\mathrm{O}$ and $^{15}_{7}\mathrm{N}$, in the units of nuclear magneton (μ_N) is $a/3$.

The magnitude of a is ___ (in integer).

Answer Key

65 questions · Subject & topic for quick revision · Official keys (IIT/IISc)

Q.No	Subject	Topic	Type	Marks	Answer
Q1	General Aptitude	English	MCQ	1	**A**
Q2	General Aptitude	Reasoning	MCQ	1	**A**
Q3	General Aptitude	Mathematical Analysis	MCQ	1	**C**
Q4	General Aptitude	Mathematical Analysis	MCQ	1	**A**
Q5	General Aptitude	Mathematical Analysis	MCQ	1	**D**
Q6	General Aptitude	English	MCQ	2	**B**
Q7	General Aptitude	Mathematical Analysis	MCQ	2	**
Q8	General Aptitude	Data Analysis	MCQ	2	**C**
Q9	General Aptitude	Reasoning	MCQ	2	**A**
Q10	General Aptitude	Geometry	MCQ	2	**
Q11	Classical Mechanics	Canonical Transformation and Poiss…	MCQ	1	**C**
Q12	Optics	Polarization	MCQ	1	**C**
Q13	Quantum Mechanics	Basics Quantum Mechanics	MCQ	1	**A**
Q14	Thermodynamics	Thermodynamic Potential	MCQ	1	**A**
Q15	Atomic and Molecular Ph…	Molecular Physics	MCQ	1	**A**
Q16	Solid State Physics	Free electron model	MCQ	1	**B**
Q17	Nuclear and Particle Phy…	Radioactivity	MCQ	1	**B**
Q18	Electronics	Diodes	MCQ	1	**A**
Q19	Nuclear and Particle Phy…	Radioactivity	MCQ	1	**C**
Q20	Electromagnetism	Magnetism in matter	MCQ	1	**C**
Q21	Atomic and Molecular Ph…	ESR/EPR/NMR	MCQ	1	**D**
Q22	Quantum Mechanics	Potential Well	MCQ	1	**B**
Q23	Classical Mechanics	Canonical Transformation and Poiss…	MCQ	1	**B**
Q24	Electronics	Logic Gates	MCQ	1	**A**
Q25	Classical Mechanics	Special theory of relativity	MCQ	1	**A**
Q26	Nuclear and Particle Phy…	Particle Physics	MCQ	1	**A**
Q27	Solid State Physics	Superconductivity	MCQ	1	**D**
Q28	Quantum Mechanics	Variational Principle	MCQ	1	**D**
Q29	Quantum Mechanics	Basics Quantum Mechanics	MCQ	1	**C**
Q30	Mathematical Physics	Vector Analysis	MSQ	1	**A; B; C**
Q31	Mathematical Physics	Complex Analysis	MSQ	1	**B; C**
Q32	Electronics	Logic Gates	NAT	1	**1 to 1**
Q33	Thermodynamics	Phase transition	NAT	1	**195.10 to 195.30**
Q34	Electromagnetism	Electrostatics	NAT	1	**4 to 4**
Q35	Thermodynamics	Kinetic theory of gases	NAT	1	**2 to 2**
Q36	Nuclear and Particle Phy…	Nuclear properties	MCQ	2	**B**

Answer Key

65 questions · Subject & topic for quick revision · Official keys (IIT/IISc)

Q.No	Subject	Topic	Type	Marks	Answer
Q37	Atomic and Molecular Ph…	Effects in atomic physics	MCQ	2	**B**
Q38	Classical Mechanics	Lagrangian and Hamiltonian	MCQ	2	**C**
Q39	Solid State Physics	Xray diffraction	MCQ	2	**B**
Q40	Electromagnetism	Electrostatics	MCQ	2	**A**
Q41	Classical Mechanics	Small Oscillations	MCQ	2	**A**
Q42	Atomic and Molecular Ph…	Effects in atomic physics	MCQ	2	**B**
Q43	Mathematical Physics	Matrices	MSQ	2	**A; B; C**
Q44	Solid State Physics	Magnetic properties of solids	MSQ	2	**A; D**
Q45	Mathematical Physics	Vector Analysis	MSQ	2	**A; B**
Q46	Electromagnetism	Image Problem	MSQ	2	**A; B; C**
Q47	Quantum Mechanics	Quantum Harmonic Oscillator	MSQ	2	**B; C; D**
Q48	Quantum Mechanics	Spin and Total Angular momentum	MSQ	2	**A; C; D**
Q49	Nuclear and Particle Phy…	Particle Physics	MSQ	2	**C; D**
Q50	Solid State Physics	Hall Effect	MSQ	2	**A; B**
Q51	Mathematical Physics	Tensors	MSQ	2	**A; B**
Q52	Solid State Physics	Magnetic properties of solids	MSQ	2	**C; D**
Q53	Atomic and Molecular Ph…	Xray spectra	MSQ	2	**A; B; C**
Q54	Solid State Physics	Lattice vibration	MSQ	2	**B; C**
Q55	Electromagnetism	Radiations	MSQ	2	**A; C**
Q56	Mathematical Physics	Fourier and Laplace transform	MSQ	2	**A; B; D**
Q57	Solid State Physics	Superconductivity	MSQ	2	**A; C**
Q58	Electronics	Transistors	NAT	2	**12 to 12**
Q59	Statistical Mechanics	Canonical ensemble	NAT	2	**2.5 to 2.5**
Q60	Classical Mechanics	Lagrangian and Hamiltonian	NAT	2	**4 to 4**
Q61	Quantum Mechanics	Perturbation Theory	NAT	2	**160 to 160**
Q62	Statistical Mechanics	Quantum Statistical Mechanics	NAT	2	**3 to 3**
Q63	Electronics	OPAMP	NAT	2	**-12 to -12**
Q64	Quantum Mechanics	Orbital angular momentum and hydr…	NAT	2	**9 to 9**
Q65	Nuclear and Particle Phy…	Shell Model	NAT	2	**2 to 3**