PhysicsByAaryan

CSIR NET · GATE · JEST · BARC – Physics

GATE Physics 2022 — Full Question Paper

Previous Year Questions with Official Answer Key

Inside this PDF

- Every GATE Physics (PH) 2022 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 2022	MCQ	1M

You should ___ when to say ___ .

(A) no / no

(B) no / know

(C) know / know

(D) know / no

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

Gate 2022	MCQ	1M

Two straight lines pass through the origin $(x_0, y_0) = (0,0)$. One of them passes through the point $(x_1, y_1) = (1,3)$ and the other passes through the point $(x_2, y_2) = (1,2)$. What is the area enclosed between the straight lines in the interval [0,1] on the x-axis?

(A) 0.5

(B) 1.0

(C) 1.5

(D) 2.0

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

Gate 2022	MCQ	1M

If

$$p:q = 1:2$$

$$q:r = 4:3$$

$$r:s = 4:5$$

and u is 50% more than s, what is the ratio $p:u$?

(A) 2 : 15

(B) 16 : 15

(C) 1:5

(D) 16:45

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

Gate 2022	MCQ	1M

Given the statements:

- P is the sister of Q .
- Q is the husband of R .
- R is the mother of S .
- T is the husband of P.

Based on the above information, T is ___ of S .

(A) the grandfather

(B) an uncle

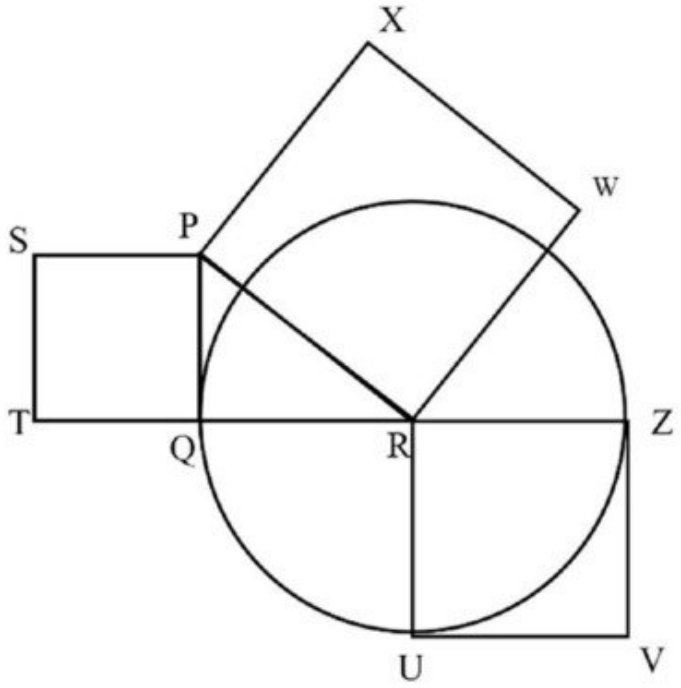
(C) the father

(D) a brother

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

Gate 2022	MCQ	1M

In the following diagram, the point R is the center of the circle. The lines PQ and ZV are tangential to the circle. The relation among the areas of the squares, PXWR, RUVZ and SPQT is



(A) Area of SPQT = Area of RUVZ = Area of PXWR

(B) Area of SPQT = Area of PXWR - Area of RUVZ

(C) Area of PXWR = Area of SPQT - Area of RUVZ

(D) Area of PXWR = Area of RUVZ - Area of SPQT

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

Gate 2022	MCQ	2M

Healthy eating is a critical component of healthy aging. When should one start eating healthy? It turns out that it is never too early. For example, babies who start eating healthy in the first year are more likely to have better overall health as they get older.

Which one of the following is the CORRECT logical inference based on the information in the above passage?

(A) Healthy eating is important for those with good health conditions, but not for others

(B) Eating healthy can be started at any age, earlier the better

(C) Eating healthy and better overall health are more correlated at a young age, but not older age

(D) Healthy eating is more important for adults than kids

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

Gate 2022	MCQ	2M

P invested ₹ 5000 per month for 6 months of a year and Q invested ₹x per month for 8 months of the year in a partnership business. The profit is shared in proportion to the total investment made in that year.

If at the end of that investment year, Q receives $\frac{4}{9}$ of the total profit, what is the value of x (in ₹)?

(A) 2500

(B) 3000

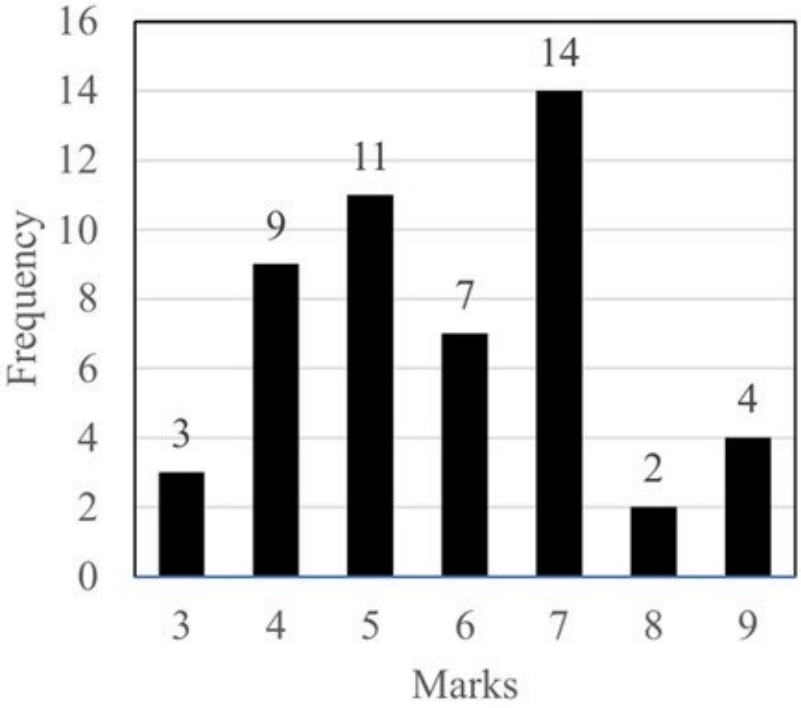
(C) 4687

(D) 8437

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

Gate 2022	MCQ	2M

The above frequency chart shows the frequency distribution of marks obtained by a set of students in an exam. From the data presented above, which one of the following is CORRECT?



(A) mean > mode > median

(B) mode > median > mean

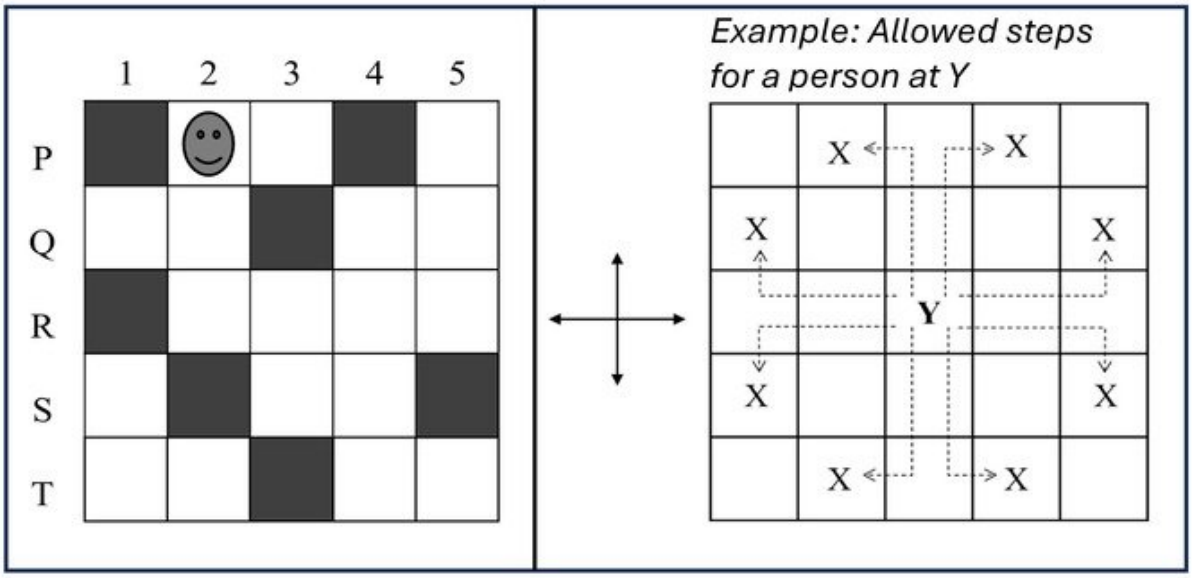
(C) mode > mean > median

(D) median > mode > mean

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

Gate 2022	MCQ	2M

In the square grid shown on the left, a person standing at P2 position is required to move to P5 position. The only movement allowed for a step involves, "two moves along one direction followed by one move in a perpendicular direction". The permissible directions for movement are shown as dotted arrows in the right. For example, a person at a given position **Y** can move only to the positions marked X on the right.



Without occupying any of the shaded squares at the end of each step, the minimum number of steps required to go from P2 to P5 is

(A) 4

(B) 5

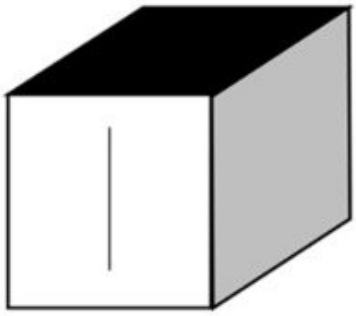
(C) 6

(D) 7

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

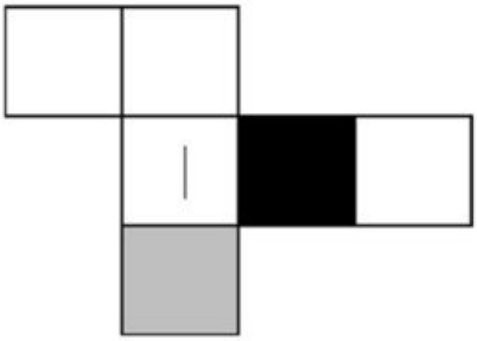
Gate 2022	MCQ	2M

Consider a cube made by folding a single sheet of paper of appropriate shape. The interior faces of the cube are all blank. However, the exterior faces that are not visible in the above view may not be blank.

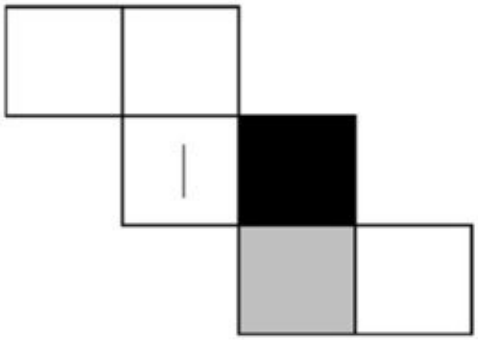


Which one of the following represents a possible unfolding of the cube?

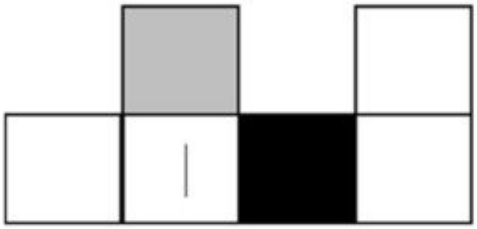
(A)



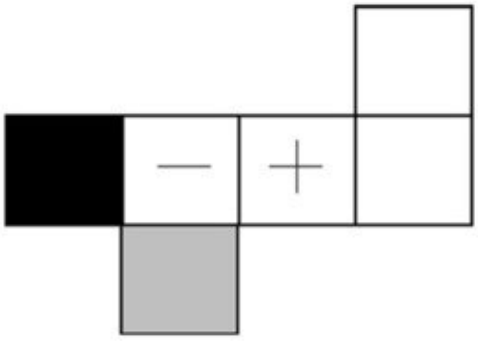
(B)



(C)



(D)

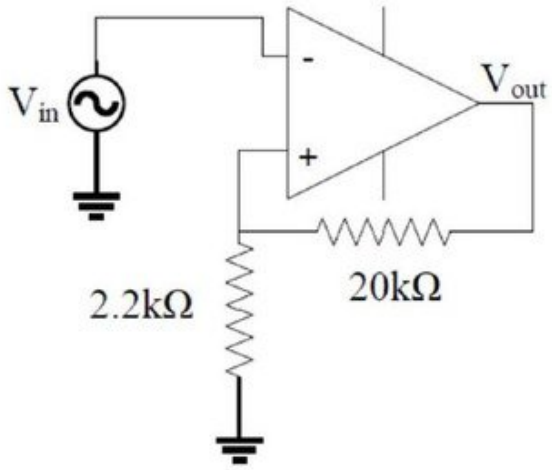


Q11. [Marks: 1 | MCQ] Electronics · OPAMP

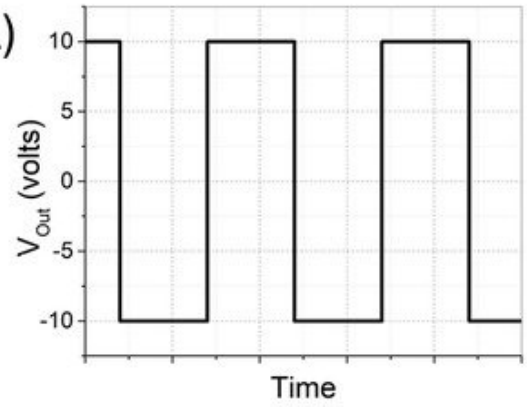
Gate 2022	MCQ	1M

For the Op-Amp circuit shown below, choose the correct output waveform corresponding to the input $V_{in} = 1.5\sin 20\pi t$ (in Volts).

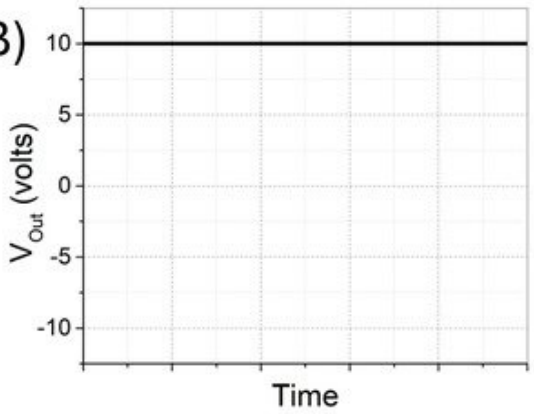
The saturation voltage for this circuit is $V_{sat} = \pm 10$ V.



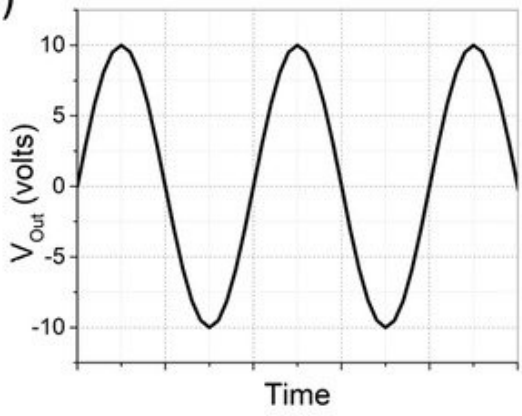
(A)



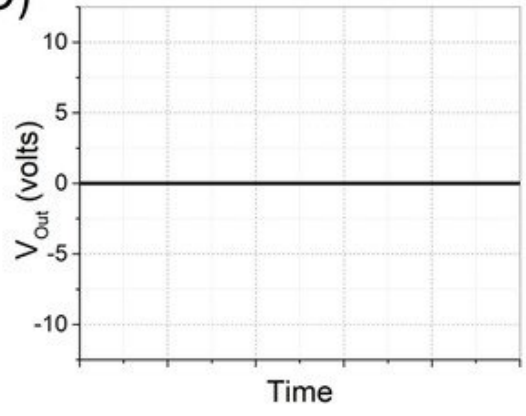
(B)



(C)



(D)



Q12. [Marks: 1 | MCQ] Nuclear and Particle Physics · Radioactivity

Gate 2022	MCQ	1M

Match the order of β-decays given in the left column to appropriate clause in the right column. Here $X(I^{\pi})$ and $Y(I^{\pi})$ are nuclei with intrinsic spin I and parity π.

1. $X\left(\frac{1}{2}^{+}\right) \rightarrow Y\left(\frac{1}{2}^{+}\right)$	i) First forbidden β-decay
2. $X\left(\frac{1}{2}^{-}\right) \rightarrow Y\left(\frac{5}{2}^{+}\right)$	ii) Second forbidden β-decay
3. $X(3^{+}) \rightarrow Y(0^{+})$	iii) Third forbidden β-decay
4. $X(4^{-}) \rightarrow Y(0^{+})$	iv) Allowed β-decay

(A) 1-i, 2-ii, 3 - iii, 4 – iv

(B) 1 - iv, 2 - i, 3 - ii, 4 – iii

(C) 1 - i, 2 - iii, 3 - ii, 4 – iv

(D) 1 - iv, 2 - ii, 3 - iii, 4 - i

Q13. [Marks: 1 | MCQ] Mathematical Physics · Matrices

Gate 2022	MCQ	1M

What is the maximum number of free independent real parameters specifying an n -dimensional orthogonal matrix?

(A) $n(n-2)$

(B) $(n-1)^2$

(C) $\frac{n(n-1)}{2}$

(D) $\frac{n(n+1)}{2}$

Q14. [Marks: 1 | MCQ] Atomic and Molecular Physics · Effects in atomic physics

Gate 2022	MCQ	1M

An excited state of Ca atom is $[\mathrm{Mg}]3\mathrm{p}^5 4\,\mathrm{s}^2 3\,\mathrm{d}^1$. The spectroscopic terms corresponding to the total orbital angular momentum are

(A) AS, P, and D

(B) P, D, and F

(C) P and D

(D) S and P

Q15. [Marks: 1 | MCQ] Electromagnetism · Electrostatics

Gate 2022	MCQ	1M

On the surface of a spherical shell enclosing a charge free region, the electrostatic potential values are as follows: One quarter of the area has potential ϕ_0, another quarter has potential $2\phi_0$ and the rest has potential $4\phi_0$. The potential at the center of the shell is

(You can use a property of the solution of Laplace's equation.)

(A) $\frac{11}{4}\phi_0$

(B) $\frac{11}{2}\phi_0$

(C) $\frac{7}{3}\phi_0$

(D) $\frac{7}{4}\phi_0$

Q16. [Marks: 1 | MCQ] Electromagnetism · Radiations

Gate 2022	MCQ	1M

A point charge q is performing simple harmonic oscillations of amplitude A at angular frequency ω. Using Larmor's formula, the power radiated by the charge is proportional to

(A) $q\omega^2A^2$

(B) $q\omega^4A^2$

(C) $q^2\omega^2A^2$

(D) $q^2\omega^4A^2$

Q17. [Marks: 1 | MCQ] Thermodynamics · Thermodynamic Potential

Gate 2022	MCQ	1M

Which of the following relationship between the internal energy U and the Helmholtz's free energy F is true?

(A) $U = -T^2\left[\frac{\partial\left(\frac{F}{T}\right)}{\partial T}\right]_V$

(B) $U = +T^2\left[\frac{\partial\left(\frac{F}{T}\right)}{\partial T}\right]_V$

(C) $U = +T\left[\frac{\partial F}{\partial T}\right]_V$

(D) $U = -T\left[\frac{\partial F}{\partial T}\right]_V$

Q18. [Marks: 1 | MCQ] Nuclear and Particle Physics · Shell Model

Gate 2022	MCQ	1M

If nucleons in a nucleus are considered to be confined in a three-dimensional cubical box, then the first four magic numbers are

(A) 2, 8, 20, 28

(B) 2, 8, 16, 24

(C) 2, 8, 14, 20

(D) 2, 10, 16, 28

Q19. [Marks: 1 | MCQ] Mathematical Physics · Differential Equations

Gate 2022	MCQ	1M

Consider the ordinary differential equation

$$y'' - 2xy' + 4y = 0$$

and its solution $y(x) = a + bx + cx^2$. Then

(A) $a = 0, c = -2b \neq 0$

(B) $c = -2a \neq 0, b = 0$

(C) $b = -2a \neq 0, c = 0$

(D) $c = 2a \neq 0, b = 0$

Q20. [Marks: 1 | MSQ] Electronics · OPAMP

Gate 2022	MSQ	1M

For an Op-Amp based negative feedback, non-inverting amplifier, which of the following statements are true?

(A) Closed loop gain < Open loop gain

(B) Closed loop bandwidth < Open loop bandwidth

(C) Closed loop input impedance > Open loop input impedance

(D) Closed loop output impedance < Open loop output impedance

Q21. [Marks: 1 | MSQ] Quantum Mechanics · Orbital angular momentum and hydrogen atom

Gate 2022	MSQ	1M

From the pairs of operators given below, identify the ones which commute. Here l and j correspond to the orbital angular momentum and the total angular momentum, respectively.

(A) l^2, j^2

(B) j^2, j_z

(C) j^2, l_z

(D) l_z, j_z

Q22. [Marks: 1 | MSQ] Atomic and Molecular Physics · Effects in atomic physics

Gate 2022	MSQ	1M

For normal Zeeman lines observed || and ⊥ to the magnetic field applied to an atom, which of the following statements are true?

(A) Only π-lines are observed || to the field

(B) σ-lines ⊥ to the field are plane polarized

(C) π-lines ⊥ to the field are plane polarized

(D) Only σ-lines are observed || to the field

Q23. [Marks: 1 | MSQ] Mathematical Physics · Matrices

Gate 2022	MSQ	1M

Pauli spin matrices satisfy

(A) $\sigma_\alpha\sigma_\beta - \sigma_\beta\sigma_\alpha = i\epsilon_{\alpha\beta\gamma}\sigma_\gamma$

(B) $\sigma_\alpha\sigma_\beta - \sigma_\beta\sigma_\alpha = 2i\epsilon_{\alpha\beta\gamma}\sigma_\gamma$

(C) $\sigma_\alpha\sigma_\beta + \sigma_\beta\sigma_\alpha = \epsilon_{\alpha\beta\gamma}\sigma_\gamma$

(D) $\sigma_\alpha\sigma_\beta + \sigma_\beta\sigma_\alpha = 2\delta_{\alpha\beta}$

Q24. [Marks: 1 | MSQ] Electromagnetism · Plasma

Gate 2022	MSQ	1M

For the refractive index $n = n_r(\omega) + in_{\text{im}}(\omega)$ of a material, which of the following statements are correct?

(A) n_r can be obtained from n_{im} and vice versa

(B) n_{im} could be zero

(C) n is an analytic function in the upper half of the complex ω plane

(D) n is independent of ω for some materials

Q25. [Marks: 1 | MSQ] Mathematical Physics · Complex Analysis

Gate 2022	MSQ	1M

Complex function $f(z) = z + |z - a|^2$ (a is a real number) is

(A) continuous at (a, a)

(B) complex-differentiable at (a, a)

(C) complex-differentiable at ($a, 0$)

(D) analytic at ($a, 0$)

Q26. [Marks: 1 | MSQ] Mathematical Physics · Fourier and Laplace transform

Gate 2022	MSQ	1M

If $g(k)$ is the Fourier transform of $f(x)$, then which of the following are true?

(A) a $g(-k) = +g^*(k)$ implies $f(x)$ is real

(B) $g(-k) = -g^*(k)$ implies $f(x)$ is purely imaginary

(C) $g(-k) = +g^*(k)$ implies $f(x)$ is purely imaginary

(D) $g(-k) = -g^*(k)$ implies $f(x)$ is real

Q27. [Marks: 1 | MSQ] Mathematical Physics · Special functions

Gate 2022	MSQ	1M

The ordinary differential equation

$$(1-x^2)y'' - xy' + 9y = 0$$

has a regular singularity at

(A) -1

(B) 0

(C) +1

(D) no finite value of x

Q28. [Marks: 1 | MSQ] Electronics · Transistors

Gate 2022	MSQ	1M

For a bipolar junction transistor, which of the following statements are true?

(A) Doping concentration of emitter region is more than that in collector and base region

(B) Only electrons participate in current conduction

(C) The current gain β depends on temperature

(D) Collector current is less than the emitter current

Q29. [Marks: 1 | NAT] Solid State Physics · Magnetic properties of solids

Gate 2022	NAT	1M

Potassium metal has electron concentration of $1.4 \times 10^{28}\ \mathrm{m}^{-3}$ and the corresponding density of states at Fermi level is $6.2 \times 10^{46}\mathrm{Joule}^{-1}\ \mathrm{m}^{-3}$. If the Pauli paramagnetic susceptibility of Potassium is $n \times 10^{-k}$ in standard scientific form, then the value of k (an integer) is ___ (Magnetic moment of electron is 9.3×10^{-24} Joule T^{-1}; permeability of free space is $4\pi \times 10^{-7}\ \mathrm{T\,mA}^{-1}$)

Q30. [Marks: 1 | NAT] Electronics · Basic Electronics

Gate 2022	NAT	1M

A power supply has internal resistance R_S and open load voltage $V_S = 5$ V. When a load resistance R_L is connected to the power supply, a voltage drop of $V_L = 4$ V is measured across the load. The value of $\frac{R_L}{R_S}$ is ___ (Round off to the nearest integer)

Q31. [Marks: 1 | NAT] Electromagnetism · Electrostatics

Gate 2022	NAT	1M

Electric field is measured along the axis of a uniformly charged disc of radius 25 cm . At a distance d from the center, the field differs by 10% from that of an infinite plane having the same charge density. The value of d is ___ cm. (Round off to one decimal place)

Q32. [Marks: 1 | NAT] Atomic and Molecular Physics · Molecular Physics

Gate 2022	NAT	1M

In a solid, a Raman line observed at $300\ \text{cm}^{-1}$ has intensity of Stokes line four times that of the anti-Stokes line. The temperature of the sample is ___ K. (Round off to the nearest integer) ($1\ \text{cm}^{-1} \equiv 1.44\ \text{K}$)

Q33. [Marks: 1 | NAT] Quantum Mechanics · Basics Quantum Mechanics

Gate 2022	NAT	1M

An electromagnetic pulse has a pulse width of 10^{-3} s. The uncertainty in the momentum of the corresponding photon is of the order of 10^{-N} kg m s^{-1}, where N is an integer. The value of N is ___

(speed of light $= 3 \times 10^{8}$ m s^{-1}, $h = 6.6 \times 10^{-34}$ J s)

Q34. [Marks: 1 | NAT] Quantum Mechanics · Potential Well

Gate 2022	NAT	1M

The wavefunction of a particle in a one-dimensional infinite well of size $2a$ at a certain time is

$$\psi(x) = \frac{1}{\sqrt{6a}}\left[\sqrt{2}\sin\left(\frac{\pi x}{a}\right) + \sqrt{3}\cos\left(\frac{\pi x}{2a}\right) + \cos\left(\frac{3\pi x}{2a}\right)\right].$$

Probability of finding the particle in $n = 2$ state at that time is ___ % (Round off to the nearest integer)

Q35. [Marks: 1 | NAT] Electromagnetism · Plasma

Gate 2022	NAT	1M

A spectrometer is used to detect plasma oscillations in a sample. The spectrometer can work in the range of $3 \times 10^{12} \text{rads}^{-1}$ to $30 \times 10^{12} \text{rads}^{-1}$. The minimum carrier concentration that can be detected by using this spectrometer is $n \times 10^{21} \text{m}^{-3}$. The value of n is ___ (Round off to two decimal places)

(Charge of an electron $= -1.6 \times 10^{-1} \text{C}$, mass of an electron $= 9.1 \times 10^{-31}$ kg and $\epsilon_0 = 8.85 \times 10^{-12} \text{C}^2 \text{N}^{-1} \text{m}^{-2}$)

Q36. [Marks: 2 | MCQ] Statistical Mechanics · Canonical ensemble

Gate 2022	MCQ	2M

Consider a non-interacting gas of spin 1 particles, each with magnetic moment μ, placed in a weak magnetic field B, such that $\frac{\mu B}{k_B T} \ll 1$. The average magnetic moment of a particle is

(A) $\frac{2\mu}{3}\left(\frac{\mu B}{k_B T}\right)$

(B) $\frac{\mu}{2}\left(\frac{\mu B}{k_B T}\right)$

(C) $\frac{\mu}{3}\left(\frac{\mu B}{k_B T}\right)$

(D) $\frac{3\mu}{4}\left(\frac{\mu B}{k_B T}\right)$

Q37. [Marks: 2 | MCQ] Thermodynamics · Laws of thermodynamics

Gate 2022	MCQ	2M

Water at 300 K can be brought to 320 K using one of the following processes.

- Process 1: Water is brought in equilibrium with a reservoir at 320 K directly.
- Process 2: Water is first brought in equilibrium with a reservoir at 310 K and then with the reservoir at 320 K .
- Process 3: Water is first brought in equilibrium with a reservoir at 350 K and then with the reservoir at 320 K .

The corresponding changes in the entropy of the universe for these processes are $\Delta S_1, \Delta S_2$ and ΔS_3, respectively. Then

(A) $\Delta S_2 > \Delta S_1 > \Delta S_3$

(B) $\Delta S_3 > \Delta S_1 > \Delta S_2$

(C) $\Delta S_3 > \Delta S_2 > \Delta S_1$

(D) $\Delta S_1 > \Delta S_2 > \Delta S_3$

Q38. [Marks: 2 | MCQ] Optics · Interference and Diffraction

Gate 2022	MCQ	2M

A student sets up Young's double slit experiment with electrons of momentum p incident normally on the slits of width w separated by distance d. In order to observe interference fringes on a screen at a distance D from the slits, which of the following conditions should be satisfied?

(A) $\frac{\hbar}{p} > \frac{Dw}{d}$

(B) $\frac{\hbar}{p} > \frac{dw}{D}$

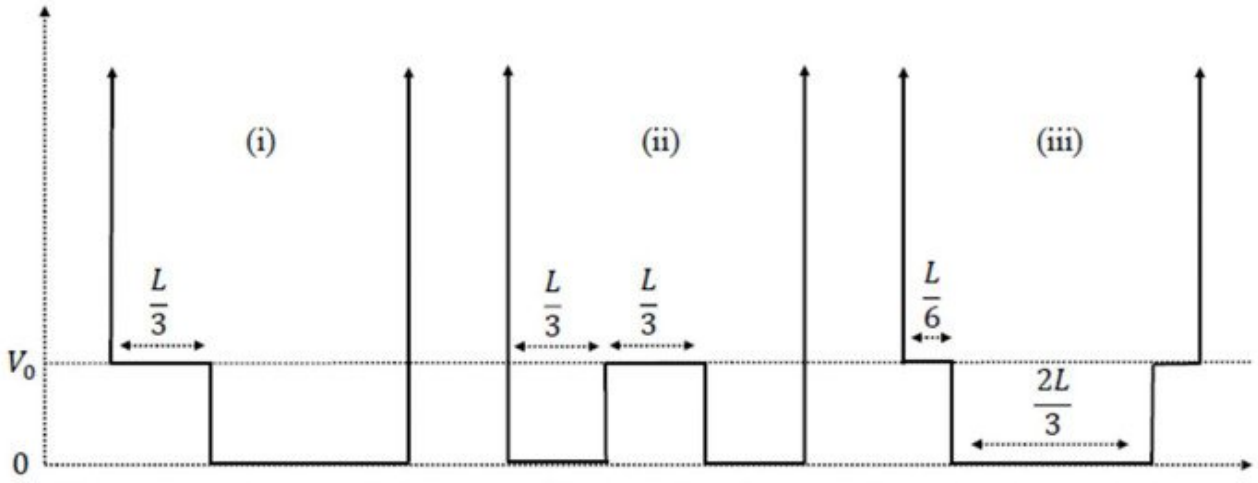
(C) $\frac{\hbar}{p} > \frac{d^2}{D}$

(D) $\frac{\hbar}{p} > \frac{d^2}{\sqrt{Dw}}$

Q39. [Marks: 2 | MCQ] Quantum Mechanics · Perturbation Theory

Gate 2022	MCQ	2M

Consider a particle in three different boxes of width L. The potential inside the boxes vary as shown in figures (i), (ii) and (iii) with $V_0 \ll \frac{\hbar^2\pi^2}{2mL^2}$. The corresponding ground-state energies of the particle are E_1, E_2 and E_3, respectively. Then



(A) $E_2 > E_1 > E_3$

(B) $E_3 > E_1 > E_2$

(C) $E_2 > E_3 > E_1$

(D) $E_3 > E_2 > E_1$

Q40. [Marks: 2 | MCQ] Quantum Mechanics · Basics Quantum Mechanics

Gate 2022	MCQ	2M

In cylindrical coordinates (s, φ, z), which of the following is a Hermitian operator?

(A) $\frac{1}{i}\frac{\partial}{\partial s}$

(B) $\frac{1}{i}\left(\frac{\partial}{\partial s}+\frac{1}{s}\right)$

(C) $\frac{1}{i}\left(\frac{\partial}{\partial s}+\frac{1}{2s}\right)$

(D) $\left(\frac{\partial}{\partial s}+\frac{1}{s}\right)$

Q41. [Marks: 2 | MCQ] Classical Mechanics · Lagrangian and Hamiltonian

Gate 2022	MCQ	2M

A particle of mass 1 kg is released from a height of 1 m above the ground. When it reaches the ground, what is the value of Hamilton's action for this motion in J s? (g is the acceleration due to gravity; take gravitation potential to be zero on the ground)

(A) $-\frac{2}{3}\sqrt{2g}$

(B) $\frac{5}{3}\sqrt{2g}$

(C) $3\sqrt{2g}$

(D) $-\frac{1}{3}\sqrt{2g}$

Q42. [Marks: 2 | MCQ] Classical Mechanics · Lagrangian and Hamiltonian

Gate 2022	MCQ	2M

If ($\dot{x}\dot{y} + \alpha xy$) is a constant of motion of a two-dimensional isotropic harmonic oscillator with Lagrangian $L = \frac{m(\dot{x}^2+\dot{y}^2)}{2} - \frac{k(x^2+y^2)}{2}$

then α is

(A) $+\frac{k}{m}$

(B) $-\frac{k}{m}$

(C) $-\frac{2k}{m}$

(D) 0

Q43. [Marks: 2 | MCQ] Statistical Mechanics · Quantum Statistical Mechanics

Gate 2022	MCQ	2M

In a two-dimensional square lattice, frequency ω of phonons in the long wavelength limit changes linearly with the wave vector k. Then the density of states of phonons is proportional to

(A) ω

(B) ω^2

(C) $\sqrt{\omega}$

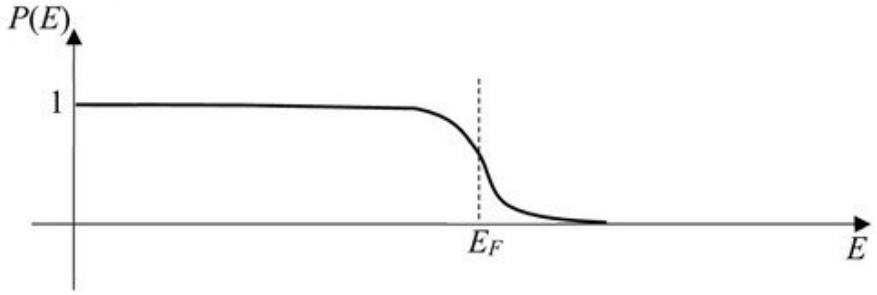
(D) $\frac{1}{\sqrt{\omega}}$

Q44. [Marks: 2 | MCQ] Solid State Physics · Superconductivity

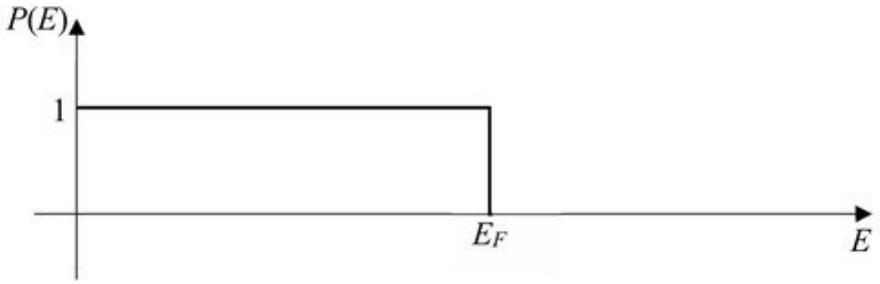
Gate 2022	MCQ	2M

At $T = 0\,\mathrm{K}$, which of the following diagram represents the occupation probability $P(E)$ of energy states of electrons in a BCS type superconductor?

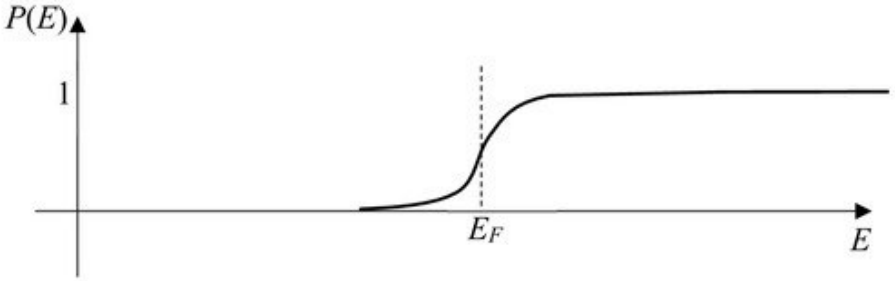
(A)



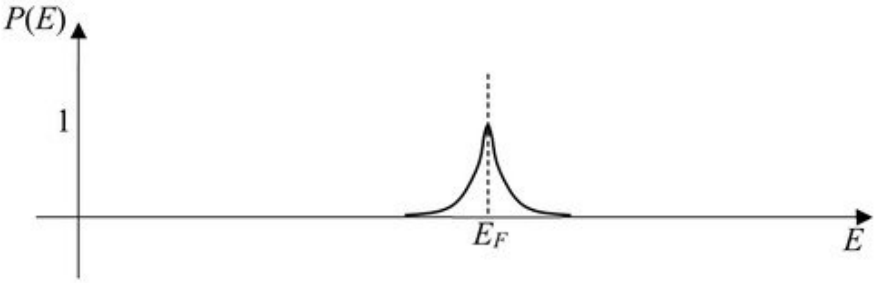
(B)



(C)



(D)



Q45. [Marks: 2 | MCQ] Quantum Mechanics · Quantum Harmonic Oscillator

Gate 2022	MCQ	2M

For a one-dimensional harmonic oscillator, the creation operator ($a^\dagger$) acting on the n^{th} state $|\psi_n\rangle$, where $n = 0,1,2, \ldots$, gives $a^\dagger|\psi_n\rangle = \sqrt{n+1}|\psi_{n+1}\rangle$. The matrix representation of the position operator $x = \sqrt{\frac{\hbar}{2m\omega}}\left(a + a^\dagger\right)$ for the first three rows and columns is

(A) $\sqrt{\frac{\hbar}{2m\omega}}\begin{pmatrix} 1 & 0 & 0 \\ 0 & \sqrt{2} & 0 \\ 0 & 0 & \sqrt{3} \end{pmatrix}$

(B) $\sqrt{\frac{\hbar}{2m\omega}}\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$

(C) $\sqrt{\frac{\hbar}{2m\omega}}\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & \sqrt{2} \\ 0 & \sqrt{2} & 0 \end{pmatrix}$

(D) $\sqrt{\frac{\hbar}{2m\omega}}\begin{pmatrix} 1 & 0 & \sqrt{3} \\ 0 & 0 & 0 \\ \sqrt{3} & 0 & 1 \end{pmatrix}$

Q46. [Marks: 2 | MCQ] Classical Mechanics · Small Oscillations

Gate 2022	MCQ	2M

A piston of mass m is fitted to an airtight horizontal cylindrical jar. The cylinder and piston have identical unit area of cross-section. The gas inside the jar has volume V and is held at pressure $P = P_{\text{atmosphere}}$. The piston is pushed inside the jar very slowly over a small distance. On releasing, the piston performs an undamped simple harmonic motion of low frequency. Assuming that the gas is ideal and no heat is exchanged with the atmosphere, the frequency of the small oscillations is proportional to

(A) $\sqrt{\frac{P}{\gamma m V}}$

(B) $\sqrt{\frac{P\gamma}{Vm}}$

(C) $\sqrt{\frac{P}{mV^{\gamma-1}}}$

(D) $\sqrt{\frac{\gamma P}{mV^{\gamma-1}}}$

Q47. [Marks: 2 | MSQ] Statistical Mechanics · Canonical ensemble

Gate 2022	MSQ	2M

A paramagnetic salt of mass m is held at temperature T in a magnetic field H. If S is the entropy of the salt and M is its magnetization, then $dG = -SdT - MdH$, where G is the Gibbs free energy. If the magnetic field is changed adiabatically by $\Delta H \to 0$ and the corresponding infinitesimal changes in entropy and temperature are ΔS and ΔT, then which of the following statements are correct

(A) $\Delta S = -\frac{1}{T}\left(\frac{\partial G}{\partial T}\right)_H \Delta T$

(B) $\Delta S = 0$

(C) $\Delta T = -\frac{\left(\frac{\partial M}{\partial T}\right)_H}{\left(\frac{\partial S}{\partial T}\right)_H}\Delta H$

(D) $\Delta T = 0$

Q48. [Marks: 2 | MSQ] Quantum Mechanics · Orbital angular momentum and hydrogen atom

Gate 2022	MSQ	2M

A particle of mass m is moving inside a hollow spherical shell of radius a so that the potential is

$$V(r) = \begin{cases} 0 \text{ for } r < a \\ \infty \text{ for } r \geq a \end{cases}$$

The ground state energy and wavefunction of the particle are E_0 and $R(r)$, respectively. Then which of the following options are correct?

(A) $E_0 = \frac{\hbar^2 \pi^2}{2ma^2}$

(B) $-\frac{\hbar^2}{2m}\frac{1}{r^2}\frac{d}{dr}\left(r^2 \frac{dR}{dr}\right) = E_0 R \ (r < a)$

(C) $-\frac{\hbar^2}{2m}\frac{1}{r^2}\frac{d^2R}{dr^2} = E_0 R \ (r < a)$

(D) $R(r) = \frac{1}{r}\sin\left(\frac{\pi r}{a}\right) \ (r < a)$

Q49. [Marks: 2 | MSQ] Classical Mechanics · Central Forces

Gate 2022	MSQ	2M

A particle of unit mass moves in a potential $V(r) = -V_0 e^{-r^2}$. If the angular momentum of the particle is $L = 0.5\sqrt{V_0}$, then which of the following statements are true?

(A) There are two equilibrium points along the radial coordinate

(B) There is one stable equilibrium point at r_1 and one unstable equilibrium point at $r_2 > r_1$

(C) There are two stable equilibrium points along the radial coordinate

(D) There is only one equilibrium point along the radial coordinate

Q50. [Marks: 2 | MSQ] Atomic and Molecular Physics · Molecular Physics

Gate 2022	MSQ	2M

In a diatomic molecule of mass M, electronic, rotational and vibrational energy scales are of magnitude E_e, E_R and E_V, respectively. The spring constant for the vibrational energy is determined by E_e. If the electron mass is m then

(A) $E_R \sim \frac{m}{M} E_e$

(B) $E_R \sim \sqrt{\frac{m}{M}} E_e$

(C) $E_V \sim \sqrt{\frac{m}{M}} E_e$

(D) $E_V \sim \left(\frac{m}{M}\right)^{1/4} E_e$

Q51. [Marks: 2 | MSQ] Solid State Physics · Tight binding model

Gate 2022	MSQ	2M

Electronic specific heat of a solid at temperature T is $C = \gamma T$, where γ is a constant related to the thermal effective mass (m_{eff}) of the electrons. Then which of the following statements are correct?

(A) n$\gamma \propto m_{eff}$

(B) m_{eff} is greater than free electron mass for all solids

(C) Temperature dependence of C depends on the dimensionality of the solid

(D) The linear temperature dependence of C is observed at $T \ll$ Debye temperature

Q52. [Marks: 2 | MSQ] Solid State Physics · Hall Effect

Gate 2022	MSQ	2M

In a Hall effect experiment on an intrinsic semiconductor, which of the following statements are correct?

(A) Hall voltage is always zero

(B) Hall voltage is negative if the effective mass of holes is larger than those of electrons

(C) Hall coefficient can be used to estimate the carrier concentration in the semiconductor

(D) Hall voltage depends on the mobility of the carriers

Q53. [Marks: 2 | MSQ] Electromagnetism · Electrostatics

Gate 2022	MSQ	2M

A parallel plate capacitor with spacing d and area of cross-section A is connected to a source of voltage V. If the plates are pulled apart quasistatically to a spacing of $2d$, then which of the following statements are correct?

(A) The force between the plates at spacing $2d$ is $\frac{1}{8}\left(\frac{\epsilon_0 A V^2}{d^2}\right)$

(B) The work done in moving the plates is $\frac{1}{8}\left(\frac{\epsilon_0 A V^2}{d}\right)$

(C) The energy transferred to the voltage source is $\frac{1}{2}\left(\frac{\epsilon_0 A V^2}{d}\right)$

(D) The energy of the capacitor reduces by $\frac{1}{4}\left(\frac{\epsilon_0 A V^2}{d}\right)$

Q54. [Marks: 2 | MSQ] Classical Mechanics · Canonical Transformation and Poisson bracket

Gate 2022	MSQ	2M

A system with time independent Hamiltonian $H(q,p)$ has two constants of motion $f(q,p)$ and $g(q,p)$. Then which of the following Poisson brackets are always zero?

(A) $\{H, f+g\}$

(B) $\{H, \{f,g\}\}$

(C) $\{H+f, g\}$

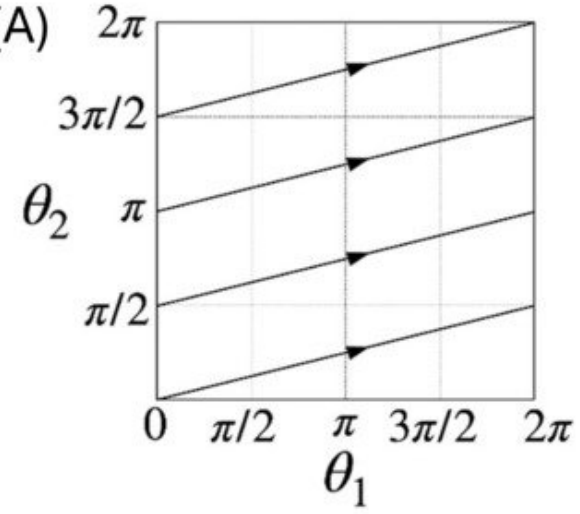
(D) $\{H, H+fg\}$

Q55. [Marks: 2 | MSQ] Classical Mechanics · Lagrangian and Hamiltonian

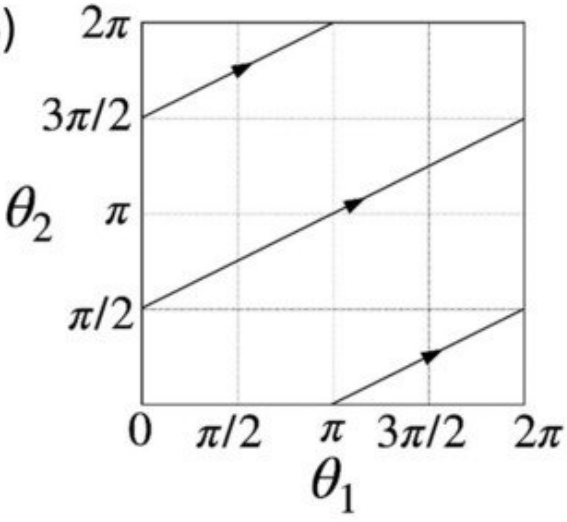
Gate 2022	MSQ	2M

In the action-angle variables ($I_1, I_2, \theta_1, \theta_2$), consider the Hamiltonian $H = 4I_1 I_2$ and $0 \leq \theta_1, \theta_2 < 2\pi$. Let $\frac{I_1}{I_2} = \frac{1}{2}$. Which of the following are possible plots of the trajectories with different initial conditions in $\theta_1 - \theta_2$ plane?

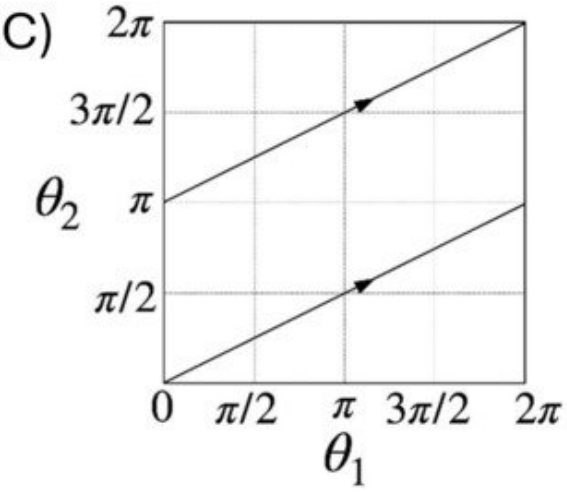
(A)



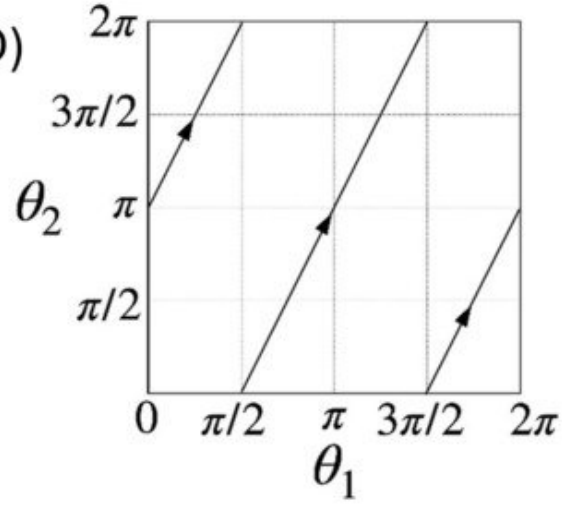
(B)



(C)



(D)



Q56. [Marks: 2 | MSQ] Quantum Mechanics · Perturbation Theory

Gate 2022	MSQ	2M

A particle of mass m in the $x-y$ plane is confined in an infinite two-dimensional well with vertices at $(0,0), (0,L), (L,L), (L,0)$. The eigenfunctions of this particle are $\psi_{n_x,n_y} = \frac{2}{L}\sin\left(\frac{n_x\pi x}{L}\right)\sin\left(\frac{n_y\pi y}{L}\right)$. If perturbation of the form $V = Cxy$, where C is a real constant, is applied, then which of the following statements are correct for the first excited state?

(A) The unperturbed energy is $\frac{3\pi^2\hbar^2}{2mL^2}$

(B) The unperturbed energy is $\frac{5\pi^2\hbar^2}{2mL^2}$

(C) First order energy shift due to the applied perturbation is zero

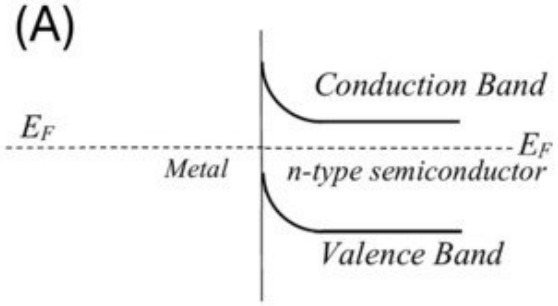
(D) The shift (δ) in energy due to the applied perturbation is determined by an equation of the form $\begin{vmatrix} a-\delta & b \\ b & a-\delta \end{vmatrix} = 0$, where a and b are real, non-zero constants

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

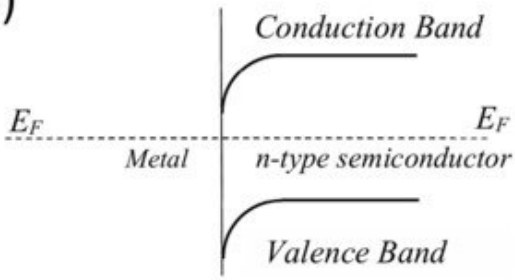
Gate 2022	MSQ	2M

A junction is formed between a metal on the left and an n-type semiconductor on the right. Before forming the junction, the Fermi level E_F of the metal lies below that of the semiconductor. Then which of the following schematics are correct for the bands and the I - V characteristics of the junction?

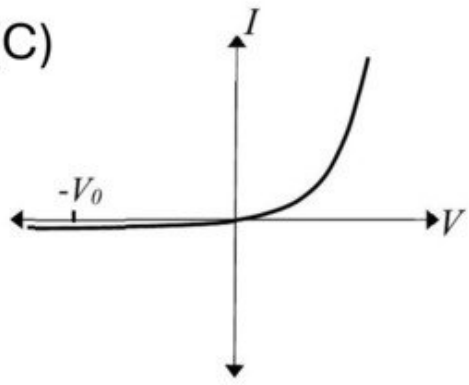
(A)



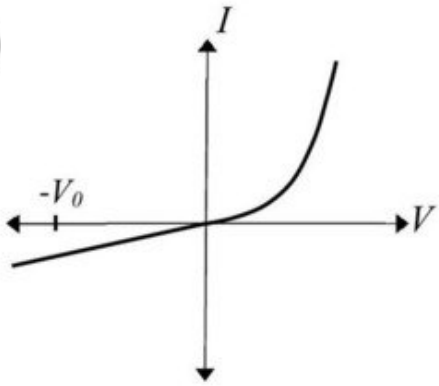
(B)



(C)



(C)



Q58. [Marks: 2 | MSQ] Optics · Polarization

Gate 2022	MSQ	2M

A plane polarized electromagnetic wave propagating in $y-z$ plane is incident at the interface of two media at Brewster's angle. Taking $z=0$ as the boundary between the two media, the electric field of the reflected wave is given by

$$\vec{E}_R = A_R \cos\left[k_0\left\{\frac{\sqrt{3}}{2}y - \frac{1}{2}z\right\} - \omega t\right]\hat{x}$$

then which among the following statements are correct?

(A) The angle of refraction is $\frac{\pi}{6}$

(B) Ratio of permittivity of the medium of refraction (ϵ_2) with respect to the medium on incidence $(\epsilon_1), \frac{\epsilon_2}{\epsilon_1} = 3$

(C) The incident wave can have components of its electric field in $y-z$ plane

(D) The angle of reflection is $\frac{\pi}{6}$

Q59. [Marks: 2 | NAT] Electronics · Logic Gates

Gate 2022	NAT	2M

The minimum number of two-input NAND gates required to implement the following Boolean expression is ___

$$Y = [A\bar{B}(C + BD) + \bar{A}\bar{B}]C$$

Q60. [Marks: 2 | NAT] Nuclear and Particle Physics · Shell Model

Gate 2022	NAT	2M

In a nucleus, the interaction $V_{so}\vec{l} \cdot \vec{s}$ is responsible for creating spin-orbit doublets. The energy difference between $p_{1/2}$ and $p_{3/2}$ states in units of $V_{so}\frac{\hbar^2}{2}$ is ___ (Round off to the nearest integer)

Q61. [Marks: 2 | NAT] Classical Mechanics · Special theory of relativity

Gate 2022	NAT	2M

Two identical particles of rest mass m_0 approach each other with equal and opposite velocity $v = 0.5c$, where c is the speed of light. The total energy of one particle as measured in the rest frame of the other is $E = \alpha m_0 c^2$. The value of α is ___ (Round off to two decimal places)

Q62. [Marks: 2 | NAT] Solid State Physics · Xray diffraction

Gate 2022	NAT	2M

In an X-Ray diffraction experiment on a solid with FCC structure, five diffraction peaks corresponding to (111), (200), (220), (311) and (222) planes are observed using 1.54Å X-rays. On using 3Å X-rays on the same solid, the number of observed peaks will be ___

Q63. [Marks: 2 | NAT] Thermodynamics · Laws of thermodynamics

Gate 2022	NAT	2M

For 1 mole of Nitrogen gas, the ratio $\left(\frac{\Delta S_I}{\Delta S_{II}}\right)$ of entropy change of the gas in processes (I) and (II) mentioned below is ___ (Round off to one decimal place)

(I) The gas is held at 1 atm and is cooled from 300 K to 77 K .

(II) The gas is liquified at 77 K .

(Take $C_p = 7.0 \text{calmol}^{-1}\,\text{K}^{-1}$, Latent heat $L = 1293.6 \text{calmol}^{-1}$)

Q64. [Marks: 2 | NAT] Atomic and Molecular Physics · Lasers

Gate 2022	NAT	2M

Frequency bandwidth Δv of a gas laser of frequency v Hz is $\Delta v = \frac{2v}{c}\sqrt{\frac{\alpha}{A}}$

where $\alpha = 3.44 \times 10^6\ \mathrm{m^2\ s^{-2}}$ at room temperature and A is the atomic mass of the lasing atom.

For $^4\mathrm{He} - {}^{20}\mathrm{Ne}$ laser (wavelength $= 633\ \mathrm{nm}$), $\Delta v = n \times 10^9\ \mathrm{Hz}$.

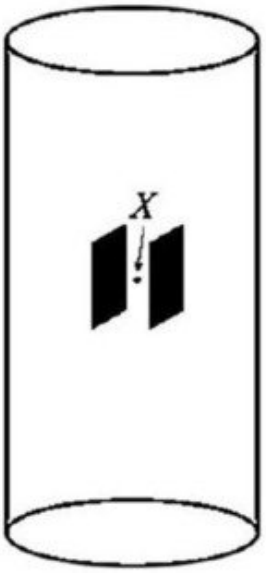
The value of n is ___ (Round off to one decimal place)

Q65. [Marks: 2 | NAT] Electromagnetism · Electrodynamics

Gate 2022	NAT	2M

A current of 1 A is flowing through a very long solenoid made of winding density 3000turns/m. As shown in the figure, a parallel plate capacitor, with plates oriented parallel to the solenoid axis and carrying surface charge density $6\epsilon_0 \text{Cm}^{-2}$, is placed at the middle of the solenoid. The momentum density of the electromagnetic field at the midpoint X of the capacitor is $n \times 10^{-13}$ N s m^{-3}. The value of n is ___ (Round off to the nearest integer)

(speed of light c=3×108 m s-1)



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	**D**
Q2	General Aptitude	Geometry	MCQ	1	**A**
Q3	General Aptitude	Mathematical Analysis	MCQ	1	**D**
Q4	General Aptitude	Reasoning	MCQ	1	**B**
Q5	General Aptitude	Geometry	MCQ	1	**B**
Q6	General Aptitude	Reasoning	MCQ	2	**B**
Q7	General Aptitude	Mathematical Analysis	MCQ	2	**B**
Q8	General Aptitude	Data Analysis	MCQ	2	**B**
Q9	General Aptitude	Reasoning	MCQ	2	**B**
Q10	General Aptitude	Reasoning	MCQ	2	**
Q11	Electronics	OPAMP	MCQ	1	**A**
Q12	Nuclear and Particle Phy…	Radioactivity	MCQ	1	**B**
Q13	Mathematical Physics	Matrices	MCQ	1	**C**
Q14	Atomic and Molecular Ph…	Effects in atomic physics	MCQ	1	**B**
Q15	Electromagnetism	Electrostatics	MCQ	1	**A**
Q16	Electromagnetism	Radiations	MCQ	1	**D**
Q17	Thermodynamics	Thermodynamic Potential	MCQ	1	**A**
Q18	Nuclear and Particle Phy…	Shell Model	MCQ	1	**C**
Q19	Mathematical Physics	Differential Equations	MCQ	1	**B**
Q20	Electronics	OPAMP	MSQ	1	**A,C,D**
Q21	Quantum Mechanics	Orbital angular momentum and hydr…	MSQ	1	**A,B,D**
Q22	Atomic and Molecular Ph…	Effects in atomic physics	MSQ	1	**B,C,D**
Q23	Mathematical Physics	Matrices	MSQ	1	**B,D**
Q24	Electromagnetism	Plasma	MSQ	1	**A,C**
Q25	Mathematical Physics	Complex Analysis	MSQ	1	**A,C**
Q26	Mathematical Physics	Fourier and Laplace transform	MSQ	1	**A,B**
Q27	Mathematical Physics	Special functions	MSQ	1	**A,C**
Q28	Electronics	Transistors	MSQ	1	**A,C,D**
Q29	Solid State Physics	Magnetic properties of solids	NAT	1	**6 to 6**
Q30	Electronics	Basic Electronics	NAT	1	**4 to 4**
Q31	Electromagnetism	Electrostatics	NAT	1	**2.4 to 2.6**
Q32	Atomic and Molecular Ph…	Molecular Physics	NAT	1	**311 to 312**
Q33	Quantum Mechanics	Basics Quantum Mechanics	NAT	1	**39 to 40**
Q34	Quantum Mechanics	Potential Well	NAT	1	**33 to 34**
Q35	Electromagnetism	Plasma	NAT	1	**2.70 to 2.96**
Q36	Statistical Mechanics	Canonical ensemble	MCQ	2	**A**

Answer Key

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

Q.No	Subject	Topic	Type	Marks	Answer
Q37	Thermodynamics	Laws of thermodynamics	MCQ	2	**B**
Q38	Optics	Interference and Diffraction	MCQ	2	**B**
Q39	Quantum Mechanics	Perturbation Theory	MCQ	2	**A**
Q40	Quantum Mechanics	Basics Quantum Mechanics	MCQ	2	**C**
Q41	Classical Mechanics	Lagrangian and Hamiltonian	MCQ	2	**D**
Q42	Classical Mechanics	Lagrangian and Hamiltonian	MCQ	2	**A**
Q43	Statistical Mechanics	Quantum Statistical Mechanics	MCQ	2	**A**
Q44	Solid State Physics	Superconductivity	MCQ	2	**A**
Q45	Quantum Mechanics	Quantum Harmonic Oscillator	MCQ	2	**C**
Q46	Classical Mechanics	Small Oscillations	MCQ	2	**B**
Q47	Statistical Mechanics	Canonical ensemble	MSQ	2	**B,C**
Q48	Quantum Mechanics	Orbital angular momentum and hydr…	MSQ	2	**A,B,D**
Q49	Classical Mechanics	Central Forces	MSQ	2	**A,B**
Q50	Atomic and Molecular Ph…	Molecular Physics	MSQ	2	**A,C**
Q51	Solid State Physics	Tight binding model	MSQ	2	**A,D**
Q52	Solid State Physics	Hall Effect	MSQ	2	**D**
Q53	Electromagnetism	Electrostatics	MSQ	2	**A,C,D**
Q54	Classical Mechanics	Canonical Transformation and Poiss…	MSQ	2	**A,B,D**
Q55	Classical Mechanics	Lagrangian and Hamiltonian	MSQ	2	**B,C**
Q56	Quantum Mechanics	Perturbation Theory	MSQ	2	**B,D**
Q57	Solid State Physics	Semiconductor Physics	MSQ	2	**A,C**
Q58	Optics	Polarization	MSQ	2	**A,B,C**
Q59	Electronics	Logic Gates	NAT	2	**3 to 3**
Q60	Nuclear and Particle Phy…	Shell Model	NAT	2	**4 to 3**
Q61	Classical Mechanics	Special theory of relativity	NAT	2	**1.65 to 1.70**
Q62	Solid State Physics	Xray diffraction	NAT	2	**1 to 1**
Q63	Thermodynamics	Laws of thermodynamics	NAT	2	**0.5 to 0.7**
Q64	Atomic and Molecular Ph…	Lasers	NAT	2	**1.2 to 1.4**
Q65	Electromagnetism	Electrodynamics	NAT	2	**2 to 2**