THE OPTIMIST CLASSES
IIT-JAM TOPPERS

MANOJ KUMAR SINGH

ABHAY

PAWAN

SATYAM

SOUMIL GIRISH SAHU

BHOOMIJA

AKSHIT AGGARWAL

SHIKHAR CHAMOLI

RAVI SINGH ADHIKARI

GAURAV JHA

SWAPNIL JOSHI

LOKESH BHATT

GOPESH VISHVAKARMA

VAIBHAV

SHASWAT CHAMOLI

CSIR-NET-JRF RESULTS 2022

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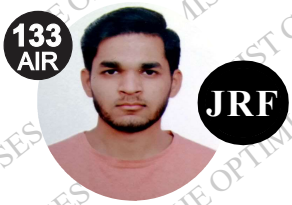


ALANKAR
UP15000162

SAHIL RANA
HR09000108

JAYESTHI
RJ11000161

DASRATH
RJ06000682

VIVEK
UK01000439

UZAIR AHMED
UP02000246

SURYA PRATAP SINGH
RJ06000232

HIMANSHU
UP10000095

CHANDAN
RJ09000159

SAIKHOM JOHNSON
MN01000196

AJAY SAINI
RJ06001744

VIKAS YADAV
RJ06001102

JYOTSNA KOHLI
UK02000262

SHYAM SUNDAR
RJ06000615

GATE PAPER 2018

SECTION - A

Q. 1 - Q. 5 carry ONE mark each.

Q1. "When she fell down the _____, she received many_____but little help".
The words that fill the blanks in the above sentence are
(a) stairs, stares (b) stairs, stairs (c) stares, stairs (d) stares, stares

Q2. "In spite of being warned repeatedly, he failed to correct his_____behaviour."
The word that best fills the blank in the above sentence is
(a) rational (b) reasonable (c) errant (d) good

Q3. For $0 \le x \le 2\pi$, sin$x$ and cos$x$ are both decreasing functions in the interval_____
(a) $\left(0, \frac{\pi}{2}\right)$ (b) $\left(\frac{\pi}{2}, \pi\right)$ (c) $\left(\pi, \frac{3\pi}{2}\right)$ (d) $\left(\frac{3\pi}{2}, 2\pi\right)$

Q4. The area of an quilateral triangle is $\sqrt{3}$. What is the perimeter of the triangle?
(a) 2 (b) 4 (c) 6 (d) 8

Q5. Arrange the following three-dimensional objects in the desecending order of their volumes:
(i) A cuboid with dimensions 10*cm*, 8*cm* and 6*cm*
(ii) A cube of side 8*cm*
(iii) A cylinder with radius 7*cm* and height 7*cm*
(iv) A sphere of radius 7*cm*

(a) (i), (ii), (iii), (iv) (b) (ii), (i), (iv), (iii)
(c) (iii), (ii), (i), (iv) (d) (iv), (iii), (ii), (i)

Q. 6 - Q. 10 carry TWO marks each.

Q6. An automobile travels from city *A* to city *B* and returns to city *A* by the same route. The speed of the vehicle during the onword and return journeys were constant at 60 *km*/*h* and 90 *km*/*h*, respectively. What is the average in *km*/*h* for the entire journey?
(a) 72 (b) 73 (c) 74 (d) 75

Q7. A set of 4 parallel lines intersect with another set of 5 parallel lines. How many parallelograms are formed?
(a) 20 (b) 48 (c) 60 (d)72

Q8. To pass a test, a candidate needs to answer at least 2 out of 3 questions correctly. A total of 6,30,000 candidates appeared for the test. Questions *A* was correctly answered by 3,30,000 candidates. Questions *B* was answered correctly by 2,60,000 candidates. Both questions *A* and *B* were answered correctly by 1,00,000

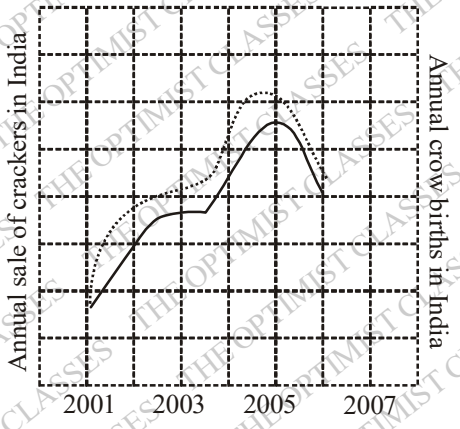
candidates. Both questions *B* and *C* were answered correctly by 90,000 candidates. Both questions *A* and *C* were answered correctly by 80,000 candidates. If the number of students answering all questions correctly is the same as the number answering none, how many candidates failed to clear the test?

(a) 30,000 (b) 2,70,000 (c) 3,90,000 (d) 4,20,000

Q9. If $x^2 + x - 1 = 0$ what is the value of $x^4 + \frac{1}{x^4}$?

(a) 1 (b) 5 (c) 7 (d) 9

Q10. In a detailed study of annual crow births in India, it was found that there was relatively no growth during the period 2002 to 2004 and a sudden spike from 2004 to 2005. In another unrelated study, it was found that the revenue from cracker sales in India which remained fairly flat from 2002 to 2004, saw a sudden spike in 2005 before declining again in 2006. The solid line in the graph below refers to anuual sale of crackers and the dashed line refers to the annual crow births in India. Choose the most appropriate interference from the above data.



(a) There is a strong correlation between crow birth and cracker sales.
(b) Cracker usage increases crow birth rate.
(c) If cracker sale declines, crow birth will decline.
(d) Increased birth rate of crows will cause an increase in the sale of crackers.

SECTION - B

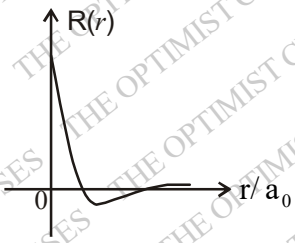
Q. 1 - Q. 25 carry ONE mark each.

Q1. The eigenvalues of a Hermitian matrix are all

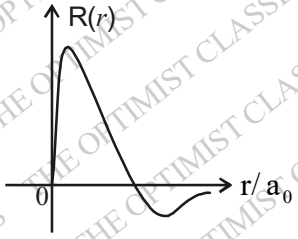
(a) real (b) imaginary (c) of modulus one (d) real and positive

Q2. Which one of the following represents the 3*p* radial wave funcion of hydrogen atom? (a_0 is the Bohr radius)

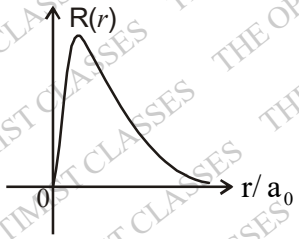
(a)



(b)



(c) 

(d) 

Q3. Given the following table,

	Group-I		Group-II
P.	Stem-Gerlach experiment	**1.**	Wave nature of particles
Q.	Zeeman effect	**2.**	Quantization of energy of electrons in the atoms
R.	Frank-Hertz experiment	**3.**	Existence of electrons spin
S.	Davisson-Germer experiment	**4.**	Space quantization of angular momentum

which one of the following correctly matches the experiment from Group-I to their inferences in Group-II?

(a) $P-2, Q-3, R-4, S-1$ (b) $P-1, Q-3, R-2, S-4$

(c) $P-3, Q-4, R-2, S-1$ (d) $P-2, Q-1, R-4, S-3$

Q4. In spherical polar coordinates (r, θ, ϕ), the unit vector $\hat{\theta}$ at $(10, \pi/4, \pi/2)$ is

(a) $\hat{k}$ (b) $\frac{1}{\sqrt{2}}\left(\hat{j}+\hat{k}\right)$ (c) $\frac{1}{\sqrt{2}}\left(-\hat{j}+\hat{k}\right)$ (d) $\frac{1}{\sqrt{2}}\left(\hat{j}-\hat{k}\right)$

Q5. The scale factors corresponding to the covariant metric tensor g_{ij} in spherical polar coordinates are

(a) $1, r^2, r^2 \sin^2\theta$ (b) $1, r^2, \sin^2\theta$ (c) 1, 1, 1 (d) $1, r, r\sin\theta$

Q6. In the context of small oscillations, which one of the following does NOT apply to the normal coordinates?

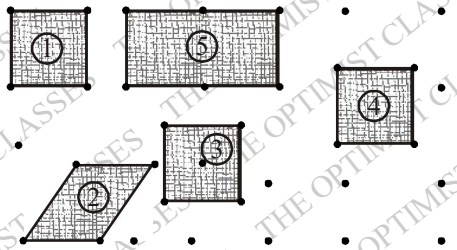
(a) Each normal coordinate has eigen-frequency associated with it

(b) The normal coordinates are orthogonal to one another

(c) The normal coordinates are all independent

(d) The potential energy of the system is a sum of squares of the normal coordinates with constant coeffi cients

Q7. For the given unit cells of a dimensional square lattice, which option lists all the primitives cells?



(a) ① and ② (b) ①, ② and ③ (c) ①,②, ③ and ④ (d)①,②,③, ④ and ⑤

Q8. Among electric field $(\vec{E})$, magnetic field $(\vec{B})$, angular momentum $(\vec{L})$, and vector potential $(\vec{A})$, which is/are odd under parity (space inversion) operation?

(a) $\vec{E}$ only (b) $\vec{E}$ & $\vec{A}$ only (c) $\vec{E}$ & $\vec{B}$ only (d) $\vec{B}$ & $\vec{L}$ only

Q9. The expression for the second overtone frequency in the vibrational absorption spectra of a diatomic molecule in terms of the harmonic frequency ω_e and anharmonicity constant x_e is

(a) $2\omega_e(1-x_e)$ (b) $2\omega_e(1-3x_e)$ (c) $3\omega_e(1-2x_e)$ (d) $3\omega_e(1-4x_e)$

Q10. Match the physical effects and order of magnitude of their energy scales given below, where $\alpha = \dfrac{e^2}{4\pi \in_0 \hbar c}$ is fine structure constant; m_e and m_p are electron and proton mass, respectively.

Group I	Group II
P: Lamb shift	**1**: $\sim \mathcal{O}\left(\alpha^2 m_e c^2\right)$
Q: Fine structure	**2**: $\sim \mathcal{O}\left(\alpha^4 m_e c^2\right)$
R: Bohr energy	**3**: $\sim \mathcal{O}\left(\alpha^4 m_e^2 c^2 / m_p\right)$
S: Hyperfine structure	**4**: $\sim \mathcal{O}\left(\alpha^5 m_e c^2\right)$

(a) P - 3, Q - 1, R - 2, S - 4 (b) P - 2, Q - 3, R - 1, S - 4

(c) P - 4, Q - 2, R - 1, S - 3 (d) P - 2, Q - 4, R - 1, S - 3

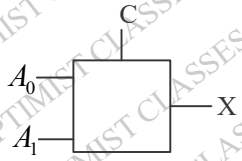
Q11. The logic expression $\bar{A}BC + \bar{A}\bar{B}C + AB\bar{C} + A\bar{B}\bar{C}$ can be simplified to

(a) A XOR C (b) A AND $\bar{C}$ (c) 0 (d) 1

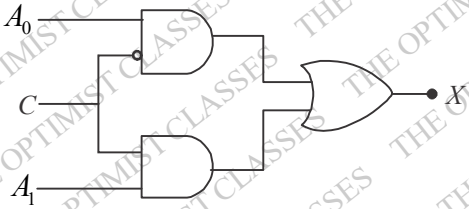
Q12. At low temperatures (T), the specific heat of common metals is descibed by (with α and β as constants)

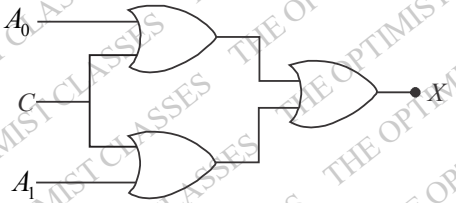
(a) $\alpha T + \beta T^3$ (b) βT^3 (c) $\exp\left(-\alpha / T\right)$ (d) $\alpha T + \beta T^5$

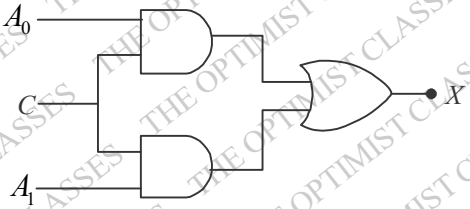
Q13. In a 2-to-1 multiplexer as shown below, the output $X = A_0$ if C = 0, and $X = A_1$ if $C = 1$.

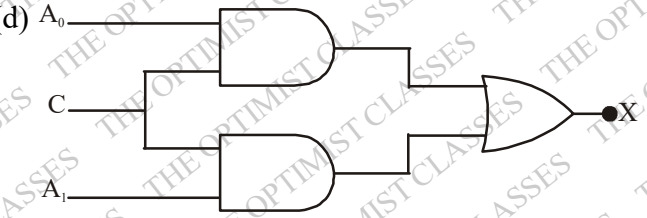


Which one of the following is the correct implementation of this multiplexer ?

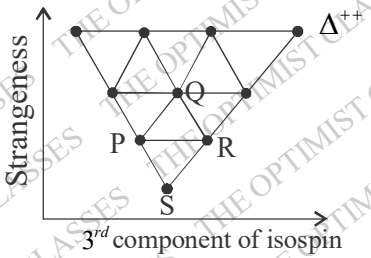
(a)


(b)


(c)


(d)


Q14. The elementary particle Ξ^0 is placed in the baryon decuplet, shown below,



(a) P (b) Q (c) R (d) S

Q15. The intrinsic/permanent electric dipole moment in the ground state of hydrogen atom is (a_0 is the Bohr radius).

(a) $-3ea_0$ (b) zero (c) ea_0 (d) $3ea_0$

Q16. The high temperature magnetic susceptiblity of solids having ions with magnetic moments can be described by $\chi \propto \frac{1}{T+\theta}$ with T as absolute temperature and θ as constant. The three behaviors i.e., paramagnetic, ferro-magnetic and anti-ferromagnetic are described, respectively, by

(a) $\theta < 0,\ \theta > 0,\ \theta = 0$ (b) $\theta > 0,\ \theta < 0,\ \theta = 0$

(c) $\theta = 0,\ \theta < 0,\ \theta > 0$ (d) $\theta = 0,\ \theta > 0,\ \theta < 0$

Q17. Which one of the following is an allowed electric dipole transition?

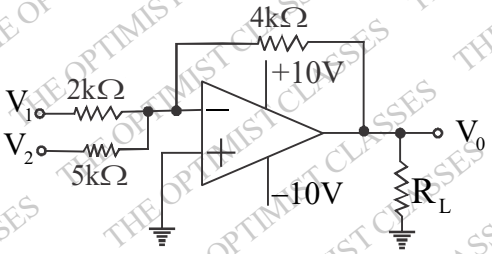
(a) $^1S_0 \rightarrow {}^3S_1$ (b) $^2P_{3/2} \rightarrow {}^2D_{5/2}$ (c) $^2D_{5/2} \rightarrow {}^2P_{1/2}$ (d) $^3P_0 \rightarrow {}^5D_0$

Q18. In the decay, $\mu^+ \rightarrow e^+ + \nu_e + X$, what is X?

(a) γ (b) $\bar{\nu}_e$ (c) ν_μ (d) $\bar{\nu}_\mu$

Q19. A spaceship is travelling with a velocity of $0.7c$ away from a station. The spaceship ejects a probe with a velocity $0.59c$ opposite to its own velocity. A person in the space station would see the probe moving at a speed Xc, where the value of X is _____(up to three decimal places).

Q20. For an operaional amplifier (ideal) circuit shown below,



if $V_1 = 1V$ and $V_2 = 2V$, the value of V_0 is _____ V (up to one decimal place).

Q21. An infinitely long straight wire is carrying a steady current I. The ratio of magnetic energy density at distance r_1 to that at $r_1 (= 2r_1)$ from the wire is _____.

Q22. A light beam of intensity I_0 is falling normally on a surface. The surface absorbs 20% of the intensity and the rest is reflected. The radiation pressure on the surface is given by XI_0 / c, where X is _____ (up to one decimal place). Here c is the speed of light.

Q23. The number of independent components of a generalelectromagnetic field tensor is _____.

Q24. If X is the dimensionally of a free electron gas, the energy (E) dependence of density of states is given by

$E^{\frac{1}{2}X-Y}$, where Y is _____.

Q25. For nucleus ^{164}Er, a $j^{\pi}=2^{+}$ state is at $90keV$. Assuming ^{164}Er to be a rigid rotor, the energy of its 4^{+} state is _____keV. (up to one decimal place).

Q.26 - Q.55 carry TWO marks each.

Q26. Given $\vec{V}_1=\hat{i}-\hat{j}$ and $\vec{V}_2=-2\hat{i}+3\hat{j}+2\hat{k}$, which one of the following $\vec{V}_3$ makes larger $\left(\vec{V}_1,\vec{V}_2,\vec{V}_3\right)$ a complete set for a three dimensional real linear vector space?.

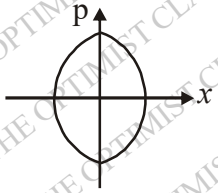
(a) $\vec{V}_3=\hat{i}+\hat{j}+4\hat{k}$ (b) $\vec{V}_3=2\hat{i}-\hat{j}+2\hat{k}$ (c) $\vec{V}_3=\hat{i}+2\hat{j}+6\hat{k}$ (d) $\vec{V}_3=2\hat{i}+\hat{j}+4\hat{k}$

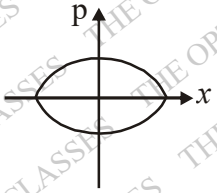
Q27. An interstellar object has speed v at the point of its shortest distance R from a star of much larger mass M.

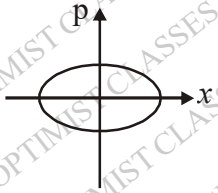
Given $v^2=2GM/R$, the trajectory of the object is

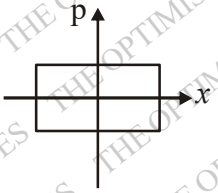
(a) circle (b) ellipse (c) parabola (d) hyperbola

Q28. A particle moves in one dimension under a potential $V(x)=\alpha|x|$ with some non-zero total energy. Which one of the following best describes the particle trajectory in the phase space

(a) 

(b) 

(c) 

(d) 

Q29. Consider an infinitely long solenoid with N turns per unit length, radius R and carrying a current $I(t)=\alpha\cos\omega t$, where α is a constant and ω is the angular frequency. The magnitude of electric field at the surface of the solenoid is

(a) $\frac{1}{2}\mu_0 NR\omega\alpha\sin\omega t$ (b) $\frac{1}{2}\mu_0\omega NR\cos\omega t$ (c) $\mu_0\omega NR\omega\alpha\sin\omega t$ (d) $\mu_0\omega NR\cos\omega t$

Q30. A constant and uniform magnetic field $\vec{B}=B_0\hat{k}$ pervades all space. Which one of the following is the correct choice for the vector potential in Coulomb gauge?

(a) $-B_0(x+y)\hat{i}$ (b) $B_0(x+y)\hat{j}$ (c) $B_0x\hat{j}$ (d) $-\frac{1}{2}B_0\left(x\hat{i}-y\hat{j}\right)$

Q31. If H is the Hamiltonian for a free particle with mass m, the commutator $\left[x,\left[x,H\right]\right]$ is

(a) $\frac{\hbar^2}{m}$ (b) $-\frac{\hbar^2}{m}$ (c) $-\frac{\hbar^2}{(2m)}$ (d) $\frac{\hbar^2}{(2m)}$

Q32. A long straight wire, having radius a and resistance per unit length r, carries a current I. The magnitude and direction of the Poynthing vector on the surface of the wire is

(a) $\frac{I^2r}{2\pi a}$, perpendicular to axis of the wire and pointing inwards

(b) $\frac{I^2r}{2\pi a}$, perpendicular to axis of the wire and pointing outwards

(c) $\frac{I^2 r}{\pi a}$, perpendicular to axis of the wire and pointing inwards.

(d) $\frac{I^2 r}{\pi a}$, perpendicular to axis of the wire and pointing outwards.

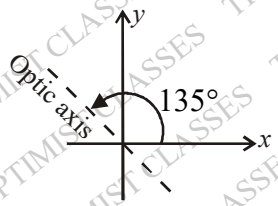
Q33. Three particles are to be distributed in four non-degenerate energy levels. The possible number of ways of distribution: (i) for distinguishable particles, and (ii) for identical Bosons, respectively, is
(a) (i) 24, (ii) 4 (b) (i) 24, (ii) 20 (c) (i) 64, (ii) 20 (d) (i) 64, (ii) 16

Q34. The term symbol for the electronic ground state of oxygen atom is
(a) ${}^1S_0$ (b) ${}^1D_2$ (c) ${}^3P_0$ (d) ${}^3P_2$

Q35. The energy dispersion for electrons in one dimensional lattice with lattice parameter a is given by $E(k) = E_0 - \frac{1}{2}W\cos ka$, where W and E_0 are constants. The effective mass of the electron near the bottom of the band is
(a) $\frac{2\hbar^2}{Wa^2}$ (b) $\frac{\hbar^2}{Wa^2}$ (c) $\frac{\hbar^2}{2Wa^2}$ (d) $\frac{\hbar^2}{4Wa^2}$

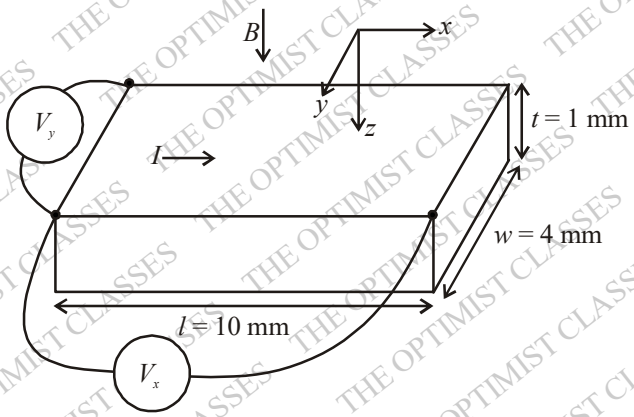
Q36. Amongst electrical resistivity (ρ), thermal conductivity (κ), specific heat (C), Young's modulus (Y), and magnetic susceptibility (χ), which quantities show a sharp change at the superconducting transition temperature?
(a) ρ, κ, C, Y (b) ρ, C, χ (c) ρ, κ, C, χ (d) κ, Y, χ

Q37. A quarter wave plate introduces a path difference of $\lambda/4$ between the two components of polarization parallel and perpendicular to the optic axis. An electromagnetic wave with $\vec{E} = (\hat{x} + \hat{y})E_0 e^{i(kz-\omega t)}$ is incident normally on a quarter wave plate which has its optic axis making an angle $135°$ with the x-axis as shown.

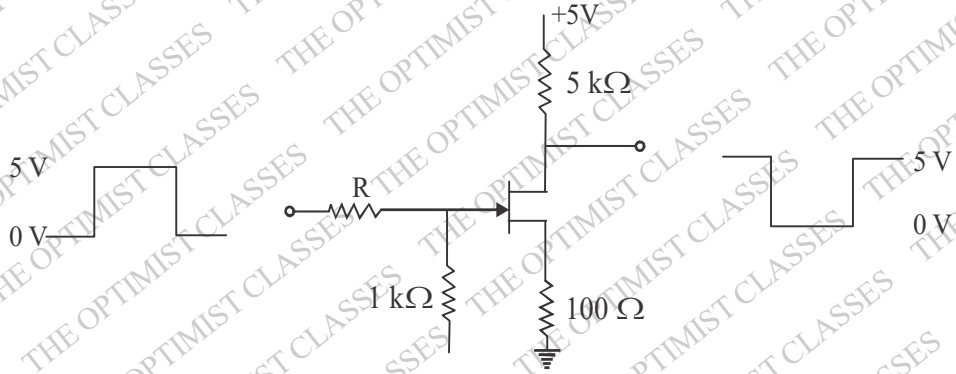


The emergent electromagnetic wave would be
(a) elliptically polarized
(b) circularly polarized
(c) linearly polarized with polarization as that of incident wave
(d) linearly polarized but with polarization at $90°$ to that of the incident wave

Q38. A p-doped semiconductor slab carries a current $I = 100\,\text{mA}$ in a magnetic field $B = 0.2\,T$ as shown. One measures $V_y = 0.25\,\text{mV}$ and $V_x = 2\,\text{mV}$. The mobility of holes in the semiconductor is _____ $\text{m}^2\text{V}^{-1}\text{s}^{-1}$ (Up to two decimal places).



Q39. An *n*-channel FET having Gate-Source switch-off voltage $V_{GS(OFF)} = -2\text{V}$ is used to invert $0-5\text{V}$ squarewave signal as shown. The maximum allowed value of *R* would be _____ $\text{k}\Omega$ (up to two decimal places).



Q40. Inside a large nucleus, a nucleon with mass $939\,\text{MeVc}^{-2}$ has Fermi momentum $1.40\,\text{fm}^{-1}$ at absolute zero temperature. Its velocity is Xc, where the value of *X* is _____(Up to two decimal palces).
$(\hbar c = 197\,\text{MeV- fm})$

Q41. 4 *MeV* γ-rays emitted by the de-excitation of ^{19}F are attributed, assuming spherical symmetry, to the transition of protons from $1\,\text{d}_{3/2}$ state to $1d_{5/2}$ state. If the contribution of spin-orbit term to the total energy is written as $C\langle \vec{l}.\vec{s} \rangle$, the magnitude of *C* is _____*MeV* (Up to one decimal place).

Q42. An α particle is emitted by a $^{230}_{90}\text{Th}$ nucleus. Assuming the potential to be purely Coulombic beyond the point of separation, the height of the Coulomb barrier is _____*MeV*

(Up to two decimal places). $\left(\frac{e^2}{4\pi\varepsilon_0} = 1.44\,\text{MeV-fm},\ r_0 = 1.30\ \text{fm}\right)$

Q43. For the transformation

$$Q = \sqrt{2q}e^{-1+2\alpha}\cos p, P = \sqrt{2q}e^{-\alpha-1}\sin p\ ,$$

(where α is a constant) to be canonical, the value of α is_____.

Q44. Given $\frac{d^2 f(x)}{dx^2} - 2\frac{df(x)}{dx} + f(x) = 0$,

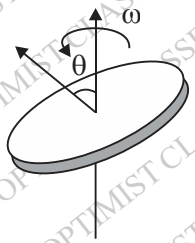
and boundary conditions $f(0) = 1$ and $f(1) = 0$, the value of $f(0.5)$ is _____.
(Up to two decimal places).

Q45. The absolute value of the integral

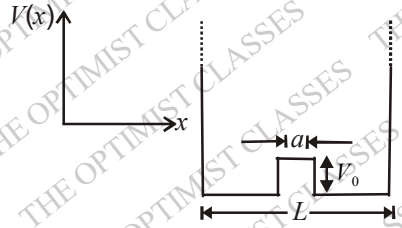
$$\int \frac{5z^3 + 3z^2}{z^2 - 4} dz,$$

over the circle $|z - 1.5| = 1$ in complex plane, is _____(Up to two decimal palces).

Q46. A uniform circular disc of mass m and radius R is rotating with angular speed ω about an axis passing through its center and making an angle $\theta = 30^o$ with the axis of the disc. If the kinetic energy of the disc is $\alpha m\omega^2 R^2$, the value of α is _____(up to two decimal places).



Q47. The ground state energy of a particle of mass m in an infinite potential well is E_0. It changes to $E_0\left(1 + \alpha \times 10^{-3}\right)$ $\left(k_B = 1.38 \times 10^{-23}\ \text{J/ K}, h = 6.6 \times 10^{-34}\ \text{J-s}\right)$, when there is a small potential bump of height $V_0 = \dfrac{\pi^2 \hbar^2}{50mL^2}$ and width $a = L/100$, as shown in the figure. The value of α is _____
(Up to two decimal places).



Q48. An electromagnetic plane wave is propagating with an intensity $I = 1.0 \times 10^5\ \text{Wm}^{-2}$ in a medium with $\in = 3 \in_0$ and $\mu = \mu_0$. The amplitude of the electric field inside the medium is _____$\times 10^{-3}$ Vm^{-1}
(Up to Two decimal place).
$\left(\in_0 = 8.85 \times 10^{-12} C^2\ \text{N}^{-1}\text{m}^{-2}, \mu_0 = 4\pi \times 10^{-7}\ \text{NA}^{-2}, c = 3 \times 10^8\ \text{ms}^{-1}\right)$

Q49. A microcanonical ensemble consists of 12 atoms with each taking either energy 0 state, or energy ε state. Both states are non-degenerate. If the total energy of this ensemble is 4ε, its entropy will be _____ k_B
(Up to One decimal place), where k_B is the Boltzmann constant.

Q50. A two-state quantum system has energy eigenvalues $\pm\epsilon$ corresponding to the normalized states $|\psi_\pm\rangle$. At time $t = 0$, the system is in quantum state $\dfrac{1}{\sqrt{2}}\left[|\psi_+\rangle + |\psi_-\rangle\right]$. The probability that the system will be in the same

state at $t = \frac{h}{(6\varepsilon)}$ is _____(up to two decimal places).

Q51 An air-conditioner maintains the room temperature at $27°C$ while the outside temperature is $47°C$. The heat conducted through the walls of the room from outside to inside due to temperature difference is $7000W$. The minimum work done by the compressor of the air-conditioner per unit time is _____ W.

Q52. Two solid spheres A and B have same emissivity. The radius of A is four times the radius of B, and temperature of A is twice the temperature of B. The ratio of the rate of heat radiated from A to that from B is_____.

Q53. The partition function of an ensemble at a temperature T is

$$Z = \left(2\cosh\frac{\varepsilon}{k_B T}\right)^N,$$

where k_B is the Boltzmann constant. The heat capacity of this ensemble at $T = \frac{\varepsilon}{k_B}$ is $X\ Nk_B$, where the value of X is _____ (Up to two decimal places).

Q54. An atom in its singlet state is subjected to a magnetic field. The Zeeman splitting of its $650nm$ spectral line is $0.03nm$. The magnitude of the field is _____Tesla (Up to Two decimal places).

Q55. The quantum effects in an ideal gas become important below a certain temperature T_Q when de-Broglie wave-length corresponding to the root mean square thermal speed becomes equal to the inter-atomic separation. For such a gas of atoms of mass 2×10^{-26} kg and number density 6.4×10^{25} m^{-3}, T_Q = _____$\times10^{-3}$ K (Up to One decimal place).

$\left(k_B = 1.38\times10^{-23}\ \text{J/ K}, h = 6.6\times10^{-34}\ \text{J-s}\right)$.

ANSWER KEY

SECTION - A

1.	(a)	2.	(c)	3.	(b)	4.	(c)
5.	(d)	6.	(a)	7.	(c)	8.	(d)
9.	(c)	10.	(a)				

SECTION - B

1.	(a)	2.	(b)	3.	(c)	4.	(d)
5.	(d)	6.	(b)	7.	(c)	8.	(b)
9.	(d)	10.	(c)	11.	(a)	12.	(a)
13.	(a)	14.	(c)	15.	(b)	16.	(c)
17.	(b)	18.	(d)	19.	(0.185 to 0.189)	20.	(–3.7 to –3.5)
21.	(4 to 4)	22.	(1.8 to 1.8)	23.	(6 to 6)	24.	(1 to 1)
25.	(297.0 to 300.1)	26.	(d)	27.	(c)	28.	(a)
29.	(a)	30.	(c)	31.	(b)	32.	(a)
33.	(c)	34.	(d)	35.	(a)	36.	(b)
37.	(c)	38.	(1.55 to 1.58)	39.	(0.70 to 0.73)	40.	(0.28 to 0.31)
41.	(1.6 to 1.6)	42.	(24.4 to 27.6)	43.	(2 to 2)	44.	(0.81 to 0.84)
45.	(81.60 to 81.80)	46.	(0.21 to 0.23)	47.	(0.78 to 0.82)	48.	(6.5 to 6.7)
49.	(6.1 to 6.3)	50.	(0.25 to 0.25)	51.	(466 to 467)	52.	(256 to 256)
53.	(0.41 to 0.43)	54.	(1.51 to 1.53)	55.	(78 to 90)		