ALL INDIA TEST SERIES
FOR
GATE (PHYSICS) 2024
Full Length Test – 01

TIME: 3 HOURS **MAXIMUM MARKS: 100**

This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and subject specific GATE paper for **85 marks**. Both these sections are compulsory.

The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-Mark each, while question numbers 6 to 10 are of 2-Mark each. The subject specific GATE paper section consists of **55** questions, out of which question numbers 11 to 35 are of 1-mark each, while question numbers 36 to 65 are of 2-mark each.

The question paper may consist of questions of **Multiple Choice Question Type** (MCQ), **Multiple Select Question Type** (MSQ) and **Numerical Answer Type** (NAT).

Question number 11 to 27 and Question number 36 to 54 are **Multiple Choice Question Type** (MCQ).

Question number 28 to 32 and Question number 55 to 58 are **Multiple Select Question Type** (MSQ)**.**

Question number 33 to 35 and Question number 59 to 65 are **Numerical Answer Type** (NAT)**.**

Multiple choice type questions will have four choices against A, B, C, D, out of which only **ONE** is the correct answer.

Multiple Select Questions will have four choices against A, B, C, D, out of which **one or more than one choice(s)** are correct.

For numerical answer type questions, each question will have a numerical answer and there will not be any choices**.**

All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of $\frac{1}{3}$ marks for a 1-mark question and $\frac{2}{3}$ marks for a 2-mark question.

There is **NO NEGATIVE MARKING** for questions of **MULTIPLE SELECT QUESTION TYPE** and **NUMERICAL ANSWER TYPE**.

Non-programmable type Calculator is allowed. Charts, graph sheets, and mathematical tables are **NOT** allowed in the Examination Hall. You must use the Scribble pad provided to you at the examination centre for all your rough work. The Scribble Pad has to be returned at the end of the examination.

GENERAL APPTITUDE

Q1-Q5 carrying ONE mark each.

Q1. A large number of students were protesting against the recent government move.

If the above statement is true, which of the following conclusions is/are logically necessary?

(I) Students should not protest

(II) Some students were not involved in the protest

(III) Some students were definitely involved in the protest

(IV) It is legal right of students to hold protest.

(a) I and III (b) II and IV (c) Only III (d) Only IV

Q2. If α is a real root of the equation $x^3+1=0$ then the value of $|3\alpha|-|-\alpha|$ is

(a) 2 (b) 3 (c) 0 (d) 1

Q3. Due to severe illness his condition was __________ day by day.

(a) deteriorate (b) deteriorated (c) deteriorate at (d) deteriorating

Q4. Seven persons A, B, C, D, E, F and G apply for a job in a company. An interview is held by the company and the following facts are observed about the marks obtained:

I. D has not scored the highest marks

II. The marks scored by E is more than the marks obtained by exactly three persons

III. F has not scored the lowest marks

IV. The marks obtained by A is less than the marks obtained by exactly five persons

V. None of B, C and F has scored the highest mark

The person obtaining the highest marks is

(a) E (b) C (c) G (d) A

Q5. A five digit number is to be formed according to following conditions:

(I) The digit 0 cannot be the leftmost digit of the number

(II) The middle digit should be 3

(III) If the unit digit is 2 the leftmost digit must be 1

(IV) There should not be repetition of any digit in the number.

How many five digit numbers can be formed under the given conditions?

(a) 2688 (b) 2760 (c) 2394 (d) 2436

Q6-Q10 carrying TWO mark each.

Q6. Elected representatives must __________ after the poor and helpless persons

(a) run (b) amaze (c) look (d) care

Q7. A right circular cylinder and a right circular cone have the same base radius. The height of cone is two times the height of cylinder. The volume of cone is less than the volume of cylinder by

(a) $\frac{50}{3}\%$ (b) $\frac{100}{3}\%$ (c) $\frac{200}{3}\%$ (d) $\frac{150}{3}\%$

Q8. There is severe debate in the academic circle about the role of corruption in government departments. Some argue that it speeds up the execution of government work while others say that it is a big burden on poor people.

What inference can be drawn from the above passage?

(a) Corruption is good for the people

(b) Corruption is bad for the poor

(c) Corruption always speeds up government work

(d) For academic persons corruption is a topic of discussion

Q9. I began to **muse** about the possibility of starting my own business.

The word that is closest in meaning to the underlined word is

(a) discuss (b) debate (c) ponder (d) amaze

Q10. X is heavier than Y. Y is lighter than Z. Z is as heavy as A.

From the above statements we can conclude that

(a) X is heavier than A (b) X is heavier than Z

(c) A is heavier than X (d) A is heavier than Y

Q11-Q35 carrying 1 mark each.

Q11. Consider a Hamiltonian system with a potential energy function given by $V(x) = x^2 - x^4$. If a particle of mass $m = 1$ oscillates about stable equilibrium point then time period of oscillation is given by

(a) $\sqrt{2}\pi$ (b) 2π (c) $\frac{\pi}{\sqrt{2}}$ (d) $\frac{\pi}{2}$

Q12. A current i in a circular loop of radius b produces a magnetic field. At a fixed point far from the loop, the strength of the magnetic field is proportional to which of the following combinations of i and b?

(a) ib (b) ib^2 (c) i^2b (d) $\frac{i}{b^2}$

Q13. The solution of $\oint_C \frac{\sin \pi z^2 + \cos \pi z^2}{(z-1)(z-2)} dz$ where C is the circle $|z| = 3$ is given by

(a) $4\pi i$ (b) $-4\pi i$ (c) $2\pi i$ (d) πi

Q14. The Potential is given by $V(x) = \begin{cases} 0, & |x| \le a \\ V_0, & |x| \ge a \end{cases}$. Then the condition on V_0 such that there is not any odd energy eigenstate is given by

(a) $V_0 < \frac{\hbar^2 \pi^2}{ma^2}$ (b) $V_0 < \frac{\hbar^2 \pi^2}{2ma^2}$ (c) $V_0 < \frac{\hbar^2 \pi^2}{4ma^2}$ (d) $V_0 < \frac{\hbar^2 \pi^2}{8ma^2}$

Q15. For a Van der Waals gas the difference of the molar heat capacities $C_P - C_V$ as a function of T and V.

(a) $C_P - C_V = R$

(b) $C_P - C_V = \frac{R}{1 - \frac{2a(V-b)}{RTV^3}}$

(c) $C_P - C_V = \frac{R}{1 - \frac{2a(V-b)^2}{RTV^3}}$

(d) $C_P - C_V = \frac{R}{1 + \frac{2a(V-b)^2}{RTV^3}}$

Q16. I start pushing a marry-go-around with torque of 10 Newton-meter. It has a moment of inertia of $100\, gm^2$. Find the rotational speed in units of $\sec^{-1}$ after 3sec by assuming that it starts from rest.

(a) 0.2 (b) 0.3 (c) 0.7 (d) 0.9

Q17. Consider X-ray diffraction from a KCl (potassium chloride) crystal. The lattice plane for which there is NO diffraction peak is

(a) (111) (b) (200) (c) (220) (d) (400)

Q18. The Laplace transform of $\cos^2 t$ is given by

(a) $\frac{1}{2}\left[\frac{s}{s^2+4} + \frac{1}{s}\right]$

(b) $\frac{1}{2}\left[\frac{s}{s^2+4} + \frac{1}{s^2}\right]$

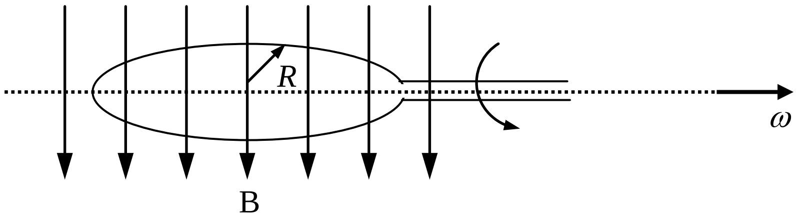
(c) $-\frac{1}{2}\left[\frac{s}{s^2+4} + \frac{1}{s}\right]$

(d) $\frac{1}{2}\left[\frac{s}{s^2+4} - \frac{1}{s}\right]$

Q19. The nuclear spin and parity of the ground state of ${}^{65}Cu_{29}$ nucleus is

(a) $\left(\frac{3}{2}\right)^+$ (b) $\left(\frac{3}{2}\right)^-$ (c) $\left(\frac{5}{2}\right)^-$ (d) $\left(\frac{7}{2}\right)^-$

Q20. A circular wire loop of radius R rotates with an angular speed ω in a uniform magnetic field **B**, as shown in the figure below. If the emf ε induced in the loop is $\varepsilon_0 \sin\omega t$, then the angular speed of the loop is



(a) $\varepsilon_0 R/B$ (b) $\tan^{-1}(\varepsilon_0/Bc)$ (c) $\varepsilon_0/(B\pi R^2)$ (d) $\varepsilon_0^2/(BR^2)$

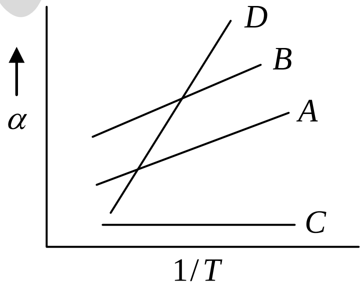
Q21. The ground state of ${}^{125}_{51}Sb$ nucleus has spin-parity $\left(\frac{7}{2}\right)^+$, while the first excited state has spin-parity $\left(\frac{9}{2}\right)^+$. The type of electromagnetic radiations emitted when the nucleus makes a transition from the first excited state to ground states is

(a) $E1$ (b) $M1$ (c) $M2$ (d) $E3$

Q22. If hydrogen atom is in ground state then average value of $r^2 - xy - z^2$ as a function of Bohr radius is given by

(a) a_0^2 (b) $2a_0^2$ (c) $3a_0^2$ (d) $\frac{3a_0^2}{2}$

Q23. The graph between total polarizability (α) and $1/T$ for different substance is shown below. If p represents the electric dipole moment, then which of the following statement is correct.



(a) $p_A > p_B > p_C > p_D$

(b) $p_A > p_B > p_D > p_C$

(c) $p_C > p_A > p_B > p_D$

(d) $p_D > p_B > p_A > p_C$

Q24. The spin parity of the ground state nucleus is 0^+. It absorbs a γ-photon and goes to the excited state. If the transition is Electric quadrupole, then the spin, parity of the excited state is

(a) 1^+ (b) 1^- (c) 2^- (d) 2^+

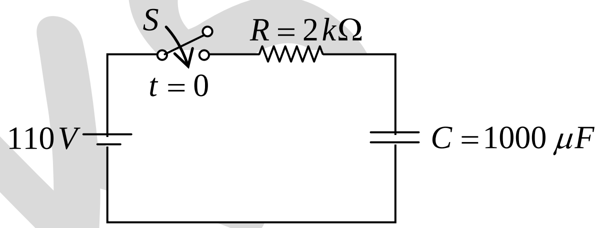
Q25. The partition function of a radiating system is given by $\ln Z = \frac{\pi^2 V (k_B T)^3}{45\hbar^3 C^3}$, the pressure of the photon gas is

(a) $\frac{\pi^2 (k_B T)^3}{15\hbar^3 C^3}$ (b) $\frac{\pi^2 (k_B T)^4}{8\hbar^3 C^3}$ (c) $\frac{\pi^2 (k_B T)^4}{45\hbar^3 C^3}$ (d) $\frac{\pi^2 (k_B T)^{3/2}}{45\hbar^3 C^3}$

Q26. The Fourier transform of a function $f(x)$ is defined as $\frac{1}{2\pi}\int_{-\infty}^{\infty} dx\, f(x) e^{ikx}$. Inverse Fourier transform of $\frac{2}{1+k^2}$ is

(a) e^x (b) e^{-x} (c) $e^{-|x|}$ (d) $\delta(x)$

Q27. A 1000 μF capacitor and a $2k\Omega$ resistor are connected in series across $110V$ dc source as shown in figure below. Then the voltage across the capacitor at 1sec after the circuit is closed



(a) 43.2 V (b) 33.2 V (c) 23.2 V (d) 13.2 V

Q28. Consider concentric spherical shells in free space in which $V = 0$ at $r = 10$ cm and $V = 10$ volts at $r = 20$ cm. Then which of the following statements are true?

(a) $V = \left(-\frac{2}{r} + 20\right)$ *Volts* (b) $\vec{E} = -\frac{2}{r^2}\hat{r}\ V/m$

(c) $\vec{D} = -\frac{17.708}{r^2}\hat{r}\ pC/m^2$ (d) $\vec{D} = \frac{17.708}{r^2}\hat{r}\ pC/m^2$

Q29. The gradient of scalar field $S(x, y, z)$ has the following characteristic(s)

(a) Line integral of a gradient is path-independent

(b) Closed line integral of a gradient is zero

(c) Gradient of S is a measure of the maximum rate of change in the field S

(d) Gradient of S is a scalar quantity

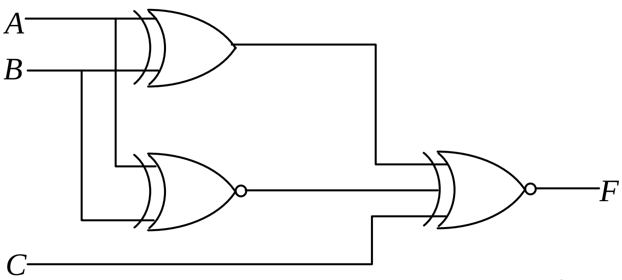
Q30. For the output F to be 1 is the logic circuit shown, the input combination should be

(a) $A=1, B=1, C=0$

(b) $A=1, B=0, C=0$

(c) $A=0, B=1, C=0$

(d) $A=0, B=0, C=1$



Q31. Which of the following statement is/are true for a wavefunction $\psi(x)=Ax^2e^{-\alpha x^2}$,

(a) It is square integrable is the region $-\infty$ to $+\infty$

(b) It is single valued

(c) $\dfrac{d\psi}{dx}$ is continuous

(d) All of the above

Q32. Which of the following crystal planes are present is the XRD diffraction pattern for KCl crystal?

(a) (200) (b) (220) (c) (111) (d) (222)

Q33. The entropy of a gas containing N particles enclosed in a volume V is given by $S=Nk_B\ln\left(\dfrac{aVE^{3/2}}{N^{5/2}}\right)$, where E is the total energy, a is a constant and k_B is the Boltzmann constant. The chemical potential μ of the system at a temperature T is given by $\mu=-k_BT\left[\ln\left(\dfrac{aVE^{3/2}}{N^{5/2}}\right)-\varsigma\right]$ The value of ς is ____________

Q34. In a three dimensions, two metal A and B, have the number density of free electrons in the ratio $N_A:N_B=1:3$. The ratio of their Fermi temperature is____________(upto 2 decimal places)

Q35. Three identical non-interacting particles, each of spin $\dfrac{1}{2}$ and mass m, are moving in a one-dimensional infinite potential well given by,

$$V(x)=\begin{cases}0 & \text{for } 0<x<a\\ \infty & \text{for } x\le 0 \text{ and } x\ge a\end{cases}$$

The energy of the lowest energy state of the system is $\dfrac{\alpha^2\pi^2\hbar^2}{2ma^2}$ the value of α is________

Q36-Q65 carrying 2 marks each.

Q36. The Hamiltonian of a one-dimensional system is $H = \frac{xp^2}{2m} - \frac{1}{2}kx$, where m and k are positive constants. The corresponding Euler-Lagrange equation for the system is

(a) $2mx\ddot{x} - m\dot{x}^2 - kx^2 = 0$ (b) $m\ddot{x} + 2\dot{x} + kx^2 = 0$

(c) $2mx\ddot{x} - m\dot{x}^2 + kx^2 = 0$ (d) $mx\ddot{x} + 2m\dot{x}^2 + kx^2 = 0$

Q37. An insulting solid sphere of radius R has a uniform positive charge density ρ. Which of the following statement is not true?

(a) the electric field at a distance $r(r < R)$ from the centre of the sphere is $\frac{\rho r}{3\varepsilon_0}$.

(b) the electric field at a distance $r(r > R)$ from the centre of the sphere is $\frac{\rho R^3}{3\varepsilon_0 r^2}$.

(c) When a charge q is taken from the centre to the surface of the sphere, its potential energy changes by $-\frac{q}{6\varepsilon_0}\rho R^2$

(d) When a charge q is taken from the centre to the surface of the sphere, its potential energy changes by $\frac{q\rho}{3\varepsilon_0}$

Q38. The energy eigenvalues E_n of a quantum system in the potential $V = cx^8$ (where $c > 0$ is a constant), for large values of the quantum number n, varies as

(a) $n^{4/3}$ (b) $n^{8/5}$ (c) $n^{5/4}$ (d) $n^{6/5}$

Q39. Which of the following statements is Not correct for superconductors?

(a) They are good conductor of electricity but poor thermal conductor.

(b) efficiency of cooper pairs in transporting the heat is lower than normal electrons.

(c) Thermal conducting shows discontinuity at critical temperature.

(d) specific heat is discontinuous at critical temperature.

Q40. A particle of mass m in two dimensions is in a potential $V(x,y)=x+2y$. Given below are two statements. Study these and pick out the correct option.

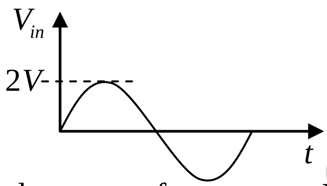
(I) p_y-2p_x is constant of motion

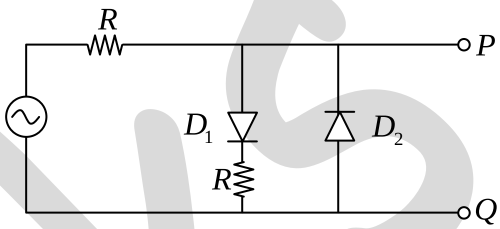
(II) p_x-2p_y is constant of motion

(a) Only I is correct (b) Only II is correct

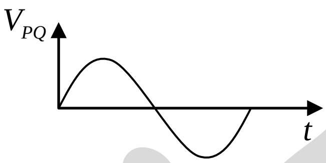
(c) Both I and II are correct (d) Neither I nor II are correct

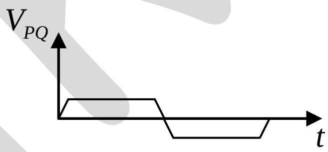
Q41. Consider the following circuit with two identical Si diodes. The input ac voltage waveform has the peak voltage $V_P=2V$, as shown

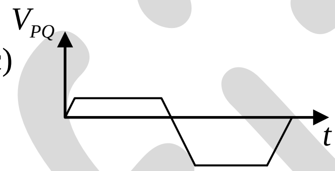


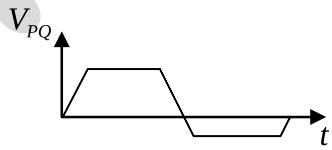


The voltage waveform across PQ will be represented by:

(a)


(b)


(c)


(d)


Q42. Two identical Bosons are placed in infinite square well of width a centered at $x=\frac{a}{2}$.

They interact weakly with one another Via potential

$$V(x_1,x_2)=-aV_0\delta(x_1-x_2)$$

where V_0 is constant with the dimensions of energy , and a is width of the well. Using first order non degenerate perturbation find the ground state energy. (use integration $\int_0^{\pi}\sin^4 t\,dt=\frac{3\pi}{8}$)

(a) $\frac{\pi^2\hbar^2}{2ma^2}-\frac{3}{2}V_0$ (b) $\frac{\pi^2\hbar^2}{ma^2}-\frac{3}{2}V_0$ (c) $\frac{\pi^2\hbar^2}{2ma^2}-\frac{3}{4}V_0$ (d) $\frac{\pi^2\hbar^2}{ma^2}-\frac{3}{4}V_0$

Q43. A particle with charge q and momentum p is moving in the horizontal plane under the action of a uniform vertical magnetic field of magnitude B. Measurements are made of the particle's trajectory to determine the "sagitta" s and half-chord length ℓ, as shown in the figure. Which of the following expressions gives the particle's momentum in terms of q, B, s, and ℓ ? (Assume $s << \ell$.)

(a) $qBs^2/2\ell$ (b) qBs^2/ℓ (c) $qB\ell/s$ (d) $qB\ell^2/2s$

Q44. An operator for a spin $\frac{1}{2}$ particle is given by $\hat{A} = \lambda\vec{s}\cdot\vec{B}$, where $\vec{B} = \frac{B}{\sqrt{2}}(\hat{x}+\hat{y})$, $\vec{s}$ denotes spinmatrices and λ is a constant. The eigenvalues of $\hat{A}$ are

(a) $\pm\frac{\lambda\hbar B}{\sqrt{2}}$ (b) $\pm\frac{\lambda\hbar B}{2}$ (c) $0, \frac{\lambda\hbar B}{2}$ (d) $0, -\frac{\lambda\hbar B}{2}$

Q45. The magnetic induction in vacuum at a plane surface of a uniform isotropic magnetic material is equal to B. The vector $\vec{B}$ forms an angle α with the normal to the surface. The relative permeability of the magnetic material is equal to μ. The magnitude of the magnetic induction B' in the magnetic material in the vicinity of its surface is:

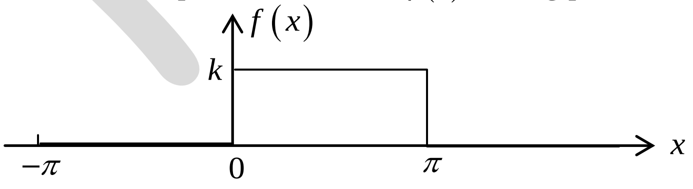
(a) $B' = B\sqrt{\mu^2\cos^2\alpha + \sin^2\alpha}$ (b) $B' = B\sqrt{1+(\mu^2+1)\sin^2\alpha}$

(c) $B' = B\sqrt{\cos^2\alpha/\mu^2 + \sin^2\alpha}$ (d) $B' = B\sqrt{\mu^2 + (1-\mu^2)\cos^2\alpha}$

Q46. Find the angular distribution and total cross section for the scattering of small marbles of mass m and radius R from a massive billiard ball of mass M and radius $2R$ $(m < M)$ (Consider the scattering as elastic, involving no frictional forces).

(a) πR^2 (b) $3\pi R^2$ (c) $5\pi R^2$ (d) $9\pi R^2$

Q47. The Fourier series of the periodic function $f(x)$ having period 2π as shown in figure:



(a) $f(x) = \frac{k}{2} + \frac{2}{\pi}\left[\sin x + \frac{1}{3}\sin 3x + \frac{1}{5}\sin 5x....\right]$

(b) $f(x) = \frac{k}{2} - \frac{2}{\pi}\left[\sin x + \frac{1}{3}\sin 3x + \frac{1}{5}\sin 5x....\right]$

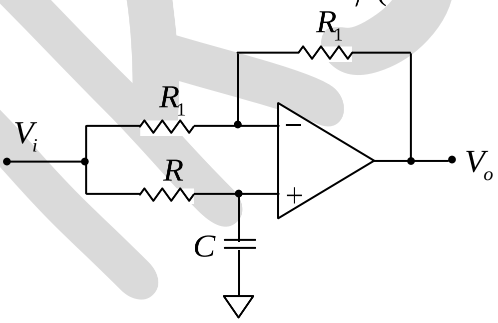
(c) $f(x) = \frac{k}{2} + \frac{2}{\pi}\left[\sin x - \frac{1}{3}\sin 3x + \frac{1}{5}\sin 5x....\right]$

(d) $f(x) = -\frac{k}{2} + \frac{2}{\pi}\left[\sin x + \frac{1}{3}\sin 3x + \frac{1}{5}\sin 5x....\right]$

Q48. At time $t=0$ a particle in the potential $V(x) = m\omega^2 x^2/2$ is described by the wave function $\psi(x,0) = A\sum_n \left(1/\sqrt{2}\right)^n \psi_n(x)$, where $\psi_n(x)$ are eigenstates of the energy with eigenvalues $E_n = (n+1/2)\hbar\omega$. You are given that $(\psi_n, \psi_{n'}) = \delta_{nn'}$. The expectation value of the energy at $t=0$ is given by (Use relation $\sum_{n=0}^{\infty}\frac{1}{x^n} = \frac{x}{x-1}$, $\sum_{n=0}^{\infty}\frac{-n}{x^{n+1}} = \frac{-1}{(x-1)^2}$ and $\sum_{n=0}^{\infty}\frac{n}{2^{n+1}} = 1$)

(a) $\frac{\hbar\omega}{2}$ (b) $\hbar\omega$ (c) $\frac{3\hbar\omega}{2}$ (d) $3\hbar\omega$

Q49. Consider the Op-Amp circuit shown in figure. If $V_i = V_1\sin(\omega t)$ and $V_o = V_2\sin(\omega t + \phi)$, then the minimum and maximum value of ϕ (in radians) are respectively



(a) $-\pi/2$ and $+\pi/2$

(b) 0 and $+\pi/2$

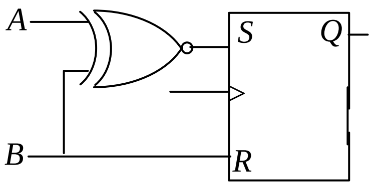
(c) $-\pi$ and 0

(d) $-\pi/2$ and 0

Q50. The electron configuration of neutral Mn atom is $[Ar]3d^5 4s^2$. The ground state of Mn^{3+} is

(a) $^5F_5$ (b) $^5F_3$ (c) $^3D_1$ (d) $^3D_2$

Q51. An AB flip-flop is constructed from an SR flip-flop as shown in figure. The expression for next state Q^+ is



(A) $\overline{AB} + AQ$ (B) $\overline{AB} + \bar{B}Q$

(C) Both A and B (D) None of the above

Q52. Which of the following interaction is not allowed?

(a) $\pi^+ + p \rightarrow \Sigma^+ + K^+$ (b) $\Omega^- \rightarrow \Lambda^0 + K^-$

(c) $K^- \rightarrow \Omega^- + K^+ + K^0$ (d) $n \rightarrow p + e^- + \bar{\nu}_e$

Q53. Two light waves having their intensities in the ratio $16:9$ interfere to produce interference pattern. What is the ratio of maximum intensity to minimum intensity in this pattern?

(a) $4:3$ (b) $25:7$ (c) $625:49$ (d) $49:1$

Q54. ${}^{40}K_{19}$ is an unstable isotope, which decays by β^+-decay. As ${}^{40}K_{19} \rightarrow {}^{40}Ar_{18} + \beta^+ + \nu_e$. Given $m\left({}^{49}K\right) = 39.96399, m\left({}^{40}Ar\right) = 39.962384$. Find the Q-value of this decay in MeV.

(a) 0.474 (b) 0.593 (c) 0.712 (d) 1.231

Q55. A particle of mass $m_1 = 3kg$ moving at velocity of $u_1 = +4m/\sec$ along the x-axis of frame S, approaches a second particle of mass $m_2 = 1kg$, moving at velocity $u_2 = -3m/\sec$ along the x-axis and after the collision the mass m_2 has velocity $U_2 = +3m/\sec$ along the x-axis then which of the following is correct

(a) The velocity of m_1 is $U_1 = +2m/\sec$

(b) The momentum of the system before collision and after collision is $9\,kg\,m/\sec$

(c) If the observer S' who has velocity $v = +2m/\sec$ relative to S frame, the momentum measured before collision is $+1kg\,m/\sec$

(d) If the observer S' who has velocity $v = +2m/\sec$ relative to S frame, the momentum measured after collision is $-1kg\,m/\sec$

Q56. A radioactive sample emits $n\,\beta$-particles in 2 sec. In next 2 sec it emits $0.75n$ β-particles, then which of the following statements are true ($\ln 2 = 0.693, \ln 3 = 1.0986$)

(a) Decay constant of the sample is $0.14\sec^{-1}$

(b) Decay constant of the sample is $0.28\sec^{-1}$

(c) Mean life of the sample is 3.5 sec

(d) Mean life of the sample is 7.0 sec

Q57. An object of mass m with non-zero angular momentum J is moving under the influence of gravitational force of a much larger mass (ignore drag). Which of the following statement(s) is (are) correct?

(a) If the total energy of the system is negative, then the orbit is either circular or elliptical

(b) The motion of m always occurs in a two-dimensional plane but angular momentum is not conserved

(c) If the total energy of the system is 0, then the orbit is a parabola

(d) If the area of the particle's bound orbit is S, then its time period is mS/J

Q58. Consider a Carnot cycle operating between two reservoirs at temperatures T_1 and T_2 s.t. $T_1 > T_2$. Let Q_1 and Q_2 represent corresponding heats entering and existing the cycle. Then which one of the followings is/are correct?

(a) $\frac{Q_1}{Q_2} = \frac{T_2}{T_1}$

(b) Entropy change of universe is zero for cycle

(c) The efficiency, $\eta = 1-(p)^{r-1}$, where p is adiabatic expansion coefficient

(d) Entropy change of source is $-Q_1/T_1$

Q59. The normalized eigenstates of a particle in a one-dimensional potential well

$$V(x) = \begin{cases} 0 & \text{if } 0 \le x \le a \\ \infty & \text{otherwise} \end{cases}$$

are given by $\psi_n(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right)$, where n = 1, 2, 3,….

The particle is subjected to a perturbation

$$V'(x) = \begin{cases} V_0 \cos\left(\frac{\pi x}{a}\right), & \text{for } 0 \le x \le \frac{a}{2} \\ 0 \quad , & \text{otherwise} \end{cases}$$

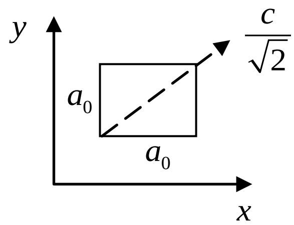
The shift in the ground state energy due to the perturbation, in the first order perturbation theory is αV_0 then value of α is________________

Q60. Two particles of identical masses move in circular orbits under a central potential $V(r) = \frac{1}{4}kr^4$. Let l_1 and l_2 be the angular momenta and r_1, r_2 be the radii of the orbits respectively. If $\frac{l_1}{l_2} = 8$, the value of $\frac{r_1}{r_2}$ is____________________

Q61. The normalized ground state wavefunciton of a hydrogen atom is given by $\psi(r) = \frac{1}{\sqrt{4\pi}} \frac{2}{a^{3/2}} e^{-r/a}$, where a is the Bohr radius and r is the distance of the electron from the nucleus, located at the origin. If the expectation value $\left\langle \frac{1}{r^2} \right\rangle$ is $\left(\frac{n}{a}\right)^2$, then the value of n is______________

Q62. An atomic transition $^1\mathrm{D} \rightarrow {}^1\mathrm{P}$ in a field of $2T$ shows Zeeman splitting. Given that the Bohr magneton $\mu_B = 1.53 \times 10^{-24} J/T$ and the wavelength corresponding to the transition is $650\,nm$, the separation in Zeeman spectral lines is ______________ $\times 10^{-12}\,m$

Q63. Area of a square plate is measured A_0 if it is rest with respect to observer . If the square plate is moving with respect to observer along its diagonal with speed $\frac{c}{\sqrt{2}}$ then area measured by the observer is αA_0 then value of α is ___________



Q64. In the unit cell of $NaCl$ structure , the radius of Na and Cl ions are $0.98\,A^0$ and $1.81\,A^0$ whereas their atomic masses are $22.99\,amu$ and $35.45\,amu$. The packing fraction of their structure is___________(3 decimal places)

Q65. The freezing point of water is 273K at atmospheric pressure $\left(1.01\times10^5\,Pa\right)$. The densities of water and ice at this temperature and pressure are $1000\,kg/m^3$ and $934\,kg/m^3$ respectively. The latent heat of fusion is $3.34\times10^5\,J/kg$. The pressure required for increasing the melting temperature of ice by 20^0C is______________ $10^5\,Pa$. (up to three decimal places)