IIT-JAM-2016

Test Series-4

MODERN PHYSICS

Duration: 2:00 Hours | **PHYSICS** | **Date: 12-01-2016**

Maximum Marks: 100

Read the following instructions carefully:

1 Attempt all the questions.

2. **Section-A** contains **30** Multiple Choice Questions (MCQ). Each question has 4 choices (a), (b), (c) and (d), for its answer, out of which **ONLY ONE** is correct. From **Q.1 to Q.10** carries 1 Marks and **Q.11 to Q.3**0 carries 2 Marks each.

3. **Section-B** contains **10** Multiple Select Questions(MSQ). Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which **ONE or MORE than ONE** is/are correct. For each correct answer you will be awarded **2 marks.**

4. Section**-C** contains **20** Numerical Answer Type (NAT) questions. From **Q.41 to Q.50** carries **1 Mark** each and **Q.51 to Q.60** carries **2 Marks** each. For each NAT type question, the value of answer in between 0 to 9.

5. In all sections, questions not attempted will result in zero mark. In Section–A (MCQ), wrong answer will result in negative marks. For all **1 mark** questions, **1/3 marks** will be deducted for each wrong answer. For all **2 marks** questions, **2/3 marks** will be deducted for each wrong answer. In Section–B (MSQ),there is no negative and no partial marking provisions. There is no negative marking in Section –C (NAT) as well.

Name of Student ....

College Name ....**Batch** ....

PART A: Multiple Choice Questions (MCQ)

(Q. 1 to Q.10: 1 marks each)

1. A proton and an electron are accelarated by the same potential difference. Suppose λ_p and λ_e denote the de broglie wavelengths of the proton and electron respectively, then

(a) $\lambda_p = \lambda_e$ (b) $\lambda_p > \lambda_e$ (c) $\lambda_p = 1836\lambda_e$ (d) $\lambda_p < \lambda_e$

2. A photon of frequency ν is scattered by an electron (having rest mass m_0), which is initially at rest. The kinetic energy of the recoil electron will be maximum if the photons are scattered at an angle

(a) 0^0 (b) 45^0 (c) 90^0 (d) 180^0

3. The time independent Schrodinger's equation of a system represents the conservation of the

(a) total energy of the system (b) total potential energy of the system
(c) total kinetic energy of the system (d) total binding energy of the system

4. The energy separation between two successive states for a infinite potential well is as following:

(a) $\Delta E \propto \sqrt{2n+1}$ (b) $\Delta E \propto (2n+1)$ (c) $\Delta E \propto (2n-1)$ (d) $\Delta E \propto n$

5. An electron is propagating along the x-axis, passes through a slit of width 1 nm. The uncertainty in the y component of its velocity after passing through the slit is

(a) $7.33\times10^5\, m/\text{sec}$ (b) $1.16\times10^5\, m/\text{sec}$ (c) $3.43\times10^5\, m/\text{sec}$ (d) $2.32\times10^5\, m/\text{sec}$

6. Suppose the wave nature of a particle is described by the following wave function:

$$\psi(x) = A\exp\left(-\frac{x^2}{a^2}\right)$$

where A is a positive real constant. The value of the momentum of the particle is

(a) 0 (b) $\hbar k$ (c) $-\hbar k$ (d) $\frac{\hbar k}{2}$

7. The operator $\left(\frac{d}{dx}+x\right)\left(\frac{d}{dx}-x\right)$ will be equivalent to

(a) $\frac{d^2}{dx^2}-x^2$ (b) $\frac{d^2}{dx^2}-x^2-1$ (c) $\frac{d^2}{dx^2}-x^2+1$ (d) $\frac{d^2}{dx^2}-1$

8. In which of the following systems will the velocity of electron in the first Bohr orbit be maximum?

(a) Hydrogen atom (b) Deuterium atom
(c) Singly ionized helium (d) Doubly ionized lithium

9. The decay constant of a radioactive sample is λ. The half-life and the average-life of the sample are respectively

(a) $\frac{1}{\lambda}$ and $\frac{\ln 2}{\lambda}$ (b) $\frac{\ln 2}{\lambda}$ and $\frac{1}{\lambda}$ (c) $\frac{\lambda}{\ln 2}$ and $\frac{1}{\lambda}$ (d) $\frac{1}{\lambda}$ and $\frac{\lambda}{\ln 2}$

10. The speed at which the mass of an electron will be double of its rest mass, is

(a) $\frac{1}{2}c$ (b) $\frac{1}{\sqrt{2}}c$ (c) $\frac{\sqrt{3}}{2}c$ (d) $\frac{1}{\sqrt{3}}c$

(Q.11 to Q. 30: 2 Marks each)

11. In the position representation, the momemtumtum operator $\hat{p}_x$ can be written as $-i\hbar\frac{\partial}{\partial x}$. Similarly, in the momentum representation, the position operator $\hat{x}_p$ can be written as

(a) $-i\hbar\frac{\partial}{\partial p}$ (b) $i\hbar\frac{\partial}{\partial p}$ (c) $-\hbar\frac{\partial}{\partial p}$ (d) $\hbar\frac{\partial}{\partial p}$

12. A beam of electrons and another beam of protons (each particle has an energy of 6.5 eV), are incident separately on two identical barriers respectively each of 10.2 eV high and 10 A^0 wide. Which of the following is a **CORRECT** statement?
(a) The electron will have greater transmission compared to proton.
(b) The proton will have greater transmission compared to electron.
(c) Both electron and proton will have equal tranmission probabilities.
(d) Neither electron nor protons can cross the barrier.

13. Consider a one-dimensional harmonic oscillator with $\hbar = m = \omega = 1$. The system is in the state

$$|\psi\rangle = Ae^{\alpha\hat{a}^\dagger}|0\rangle$$

where α is a complex number, $|0\rangle$ is the ground state of the harmonic oscillator, $\hat{a}^\dagger$ is the creation operator. The normalization constant A is given by

(a) 1 (b) $e^{-\alpha^2/2}$ (c) $e^{-\alpha\hat{a}/2}$ (d) $e^{-\alpha\alpha^\dagger/2}$

14. Suppose a particle of mass m is moving under a one-dimensional potential $V(x)$ has the following form of wavefunction:

$$\psi(x) = \frac{A}{x^2+a^2}(a>0)$$

where A is the normalization constant. The energy of the particle in the given state is 0. The one dimensional potential $V(x)$ will be of the following form:

(a) $\frac{\hbar^2}{m}\frac{2x^2-a^2}{(x^2+a^2)^2}$ (b) $\frac{\hbar^2}{m}\frac{3x^2-a^2}{(x^2+a^2)^2}$ (c) $\frac{\hbar^2}{m}\frac{3x^2-a^2}{(x^2+a^2)}$ (d) $\frac{\hbar^2}{m}\frac{x^2-2a^2}{(x^2+a^2)}$

15. A ball bounces off earth. You are asked to solve this quantum mechanically assuming the earth is a infinitely hard sphere. Which one of the following wave functions for the ball that can represent a physically admissible solution with $k>0$?

(a) $\psi = A\frac{e^{-kx}}{x}$ (b) $\psi = Axe^{-kx^2}$ (c) $\psi = -Axe^{kx}$ (d) $\psi = Ae^{-kx^2}$

16. A town has a population of 1 million. The average electric power needed per person is 300 W. A reactor is to be designed to supply power to this town. The efficiency with which thermal power is converted into electric power is aimed at 25%. The number of fissions that should take place every day will be (Assume 200 MeV of thermal energy to come form each fission event)

(a) 0.375×10^{20} (b) 0.375×10^{24} (c) 3.24×10^{24} (d) 3.24×10^{20}

17. Consider a beam of electrons each of mass 'm' and energy E ($>V_0$) is incident on the following potential:

$$V(x) = \begin{cases} 0 & \text{for} \quad x<0 \\ V_0 & \text{for} \quad 0\le x\le a \\ 0 & \text{for} \quad x>a \end{cases}$$

In the limit $E \to V_0$, the transmission coefficient will become

(a) $\dfrac{1}{1+\dfrac{mV_0a^2}{2\hbar^2}}$ (b) $\dfrac{1}{1+\dfrac{mV_0a^2}{\hbar^2}}$ (c) $\dfrac{mV_0a^2}{2\hbar^2}$ (d) $1+\dfrac{mV_0a^2}{2\hbar^2}$

18. Consider a particle of '*m*' is moving along x-axis and Hamiltonian of the system is $\hat{H} = -\varepsilon \dfrac{d^2}{dx^2} + 16\varepsilon \hat{x}^2$, where ε is real constant having dimension of energy. If the state of the particle is of the form e^{-2x^2}, then the energy of the particle will be

(a) ε (b) 2ε (c) 4ε (d) 16ε

19. For a relativistic particle, the ratio of the kinetic energy to the total energy of the particle is

(a) $1-\sqrt{1-\dfrac{v^2}{c^2}}$ (b) $\sqrt{1-\dfrac{v^2}{c^2}}$ (c) $\left(1-\dfrac{v^2}{c^2}\right)^{3/2}$ (d) $1-\left(1-\dfrac{v^2}{c^2}\right)^{3/2}$

20. Two metal bars having the same proper length l_0 move lengthwise toward each other parallel to common axis with the same velocity *v* relative to the laboratory frame of reference. The length of the each metal bar measured in the reference frame fixed to the other metal bar, is

(a) $l_0\left(1-\dfrac{v^2}{c^2}\right)/\left(1+\dfrac{v^2}{c^2}\right)$ (b) $l_0\left(1+\dfrac{v^2}{c^2}\right)/\left(1-\dfrac{v^2}{c^2}\right)$ (c) $l_0\left(1-\dfrac{v^2}{c^2}\right)$ (d) $l_0\sqrt{1-\dfrac{v^2}{c^2}}$

21. An atom of mass *M* can be excited to a state of mass $M+\Delta$ by photon capture. The fre quency of the photon which can cause this transition is

(a) $\dfrac{\Delta c^2}{h}$ (b) $\dfrac{\Delta^2 c^2}{2Mh}$ (c) $\dfrac{\Delta c^2(2M+\Delta)}{2Mh}$ (d) $\dfrac{\Delta c^2(2M+\Delta)}{h}$

22. A rod of length *l* carries a total charge *q* distributed uniformly. If this is observed in a frame moving with a speed *v* along the rod, the charge per unit length measured by the moving observer will be

(a) $\dfrac{q}{l}\left(1-\dfrac{v^2}{c^2}\right)$ (b) $\dfrac{q}{l}\sqrt{1-\dfrac{v^2}{c^2}}$ (c) $\dfrac{q}{l\sqrt{1-\dfrac{v^2}{c^2}}}$ (d) $\dfrac{q}{l\left(1-\dfrac{v^2}{c^2}\right)}$

23. The binding energy of a light nucleus (*Z, A*) in MeV is given by the approximate formula:

$$B(Z,A) \approx 16A - 20A^{2/3} - \frac{3}{4}z^2A^{-1/3} + 30\frac{(N-Z)^2}{A}$$

where $N = A - Z$ is the neutron number.The value of *Z* of the most stable isobar for a given *A* is

(a) $\dfrac{A}{2}\left(1-\dfrac{A^{2/3}}{160}\right)^{-1}$ (b) $\dfrac{A}{2}\left(1-\dfrac{A^{2/3}}{120}\right)^{-1}$ (c) $\dfrac{A}{2}\left(1+\dfrac{A^{4/3}}{120}\right)^{-1}$ (d) $\dfrac{A}{2}\left(1-\dfrac{A^{4/3}}{160}\right)^{-1}$

24. Suppose the wave-function corresponding to a particle is given as a Gaussian wave packet:

$$\psi(x) = ae^{-\alpha^2x^2/2}e^{ikx}$$

where a, α and k constants. The probability current density of the wave packet will be

(a) $\dfrac{\hbar k}{2m}|a|^2 e^{-\alpha^2x^2}$ (b) $\dfrac{3\hbar k}{2m}|a|^2 e^{-\alpha^2x^2}$ (c) $\dfrac{3\hbar k}{m}|a|^2 e^{-\alpha^2x^2}$ (d) $\dfrac{\hbar k}{m}|a|^2 e^{-\alpha^2x^2}$

25. Let $\hat{x}$ and $\hat{p}_x$ denotes the coordinate and momentum operators respectively, satisfying the canonical commutation relation $[\hat{x}, \hat{p}_x] = i$ in natural units $(\hbar = 1)$. Then the commutator $\left[\hat{x}, \hat{p}_x e^{-\hat{p}_x}\right]$ is

(a) $i(1-\hat{p}_x)e^{-\hat{p}_x}$ (b) $i\left(1-\hat{p}_x^2\right)e^{-\hat{p}_x}$ (c) $i\left(1-e^{-\hat{p}_x}\right)$ (d) $i\hat{p}_x e^{-\hat{p}_x}$

26. If an operator $\hat{A}$ is such that $\hat{A}\varphi_1 = \varphi_2, \hat{A}\varphi_2 = \varphi_3$ and $\hat{A}\varphi_3 = \varphi_1$, then the expectation value of the observable corresponding to $\hat{A}$ in the state $\psi = \frac{1}{2}\varphi_1 + \frac{1}{\sqrt{2}}\varphi_2 + \frac{1}{2}\varphi_3$ is

(a) $\frac{1}{2}+\frac{1}{\sqrt{2}}$ (b) $\frac{1}{4}+\frac{1}{\sqrt{2}}$ (c) $\frac{1}{4}+\frac{1}{2\sqrt{2}}$ (d) none of these

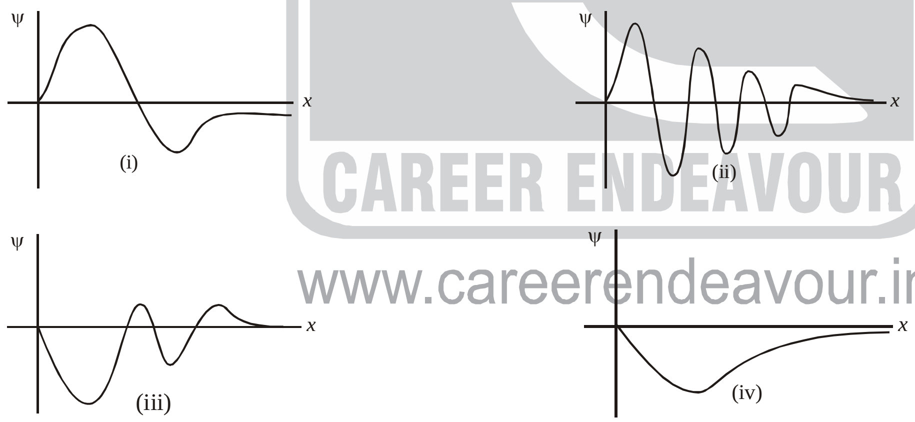
27. A one-dimensional quantum harmonic oscillator is in its ground state

$$\psi_0(x) = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4} e^{-m\omega x^2/2\hbar}$$

Two experiments, [A] and [B], are performed on the system. In [A], the frequency ω of the oscillator is suddenly doubled, while in [B] the frequency ω is suddenly halved. If p_A and p_B denote the probability in each case that the system is found in its new ground state immediately after the frequency change, which of the following is true ?

(a) $p_A = \sqrt{2}p_B$ (b) $p_A = 2p_B$ (c) $p_A = p_B$ (d) $p_A = p_B$

28. A quantum particle in one dimension x moves under the influence of a potential that supports bound states. Plotted below are the wave functions ψ vs x corresponding to four eigenstates of energy. Identify the wave functions corresponding to the ground state and the highest energy state among those shown:



(a) (i) corresponds to the ground state and (iii) to the highest energy state.
(b) (ii) corresponds to the ground state and (iv) to the highest energy state.
(c) (iv) corresponds to the ground state and (ii) to the highest energy state.
(d) None of these is the ground state and (ii) corresponds to the highest energy state.

29. A particle is in its first excited state in a finite square well potential from $x = -L/2$ to $x = L/2$. At a particular instant, the maximum value of the wave function is A, which occurs at $x = L/3$. Therefore, the value of the wave function at $x = L/2$ is

(a) $\frac{A}{4}$ (b) $\frac{A}{2}$ (c) $\frac{A}{\sqrt{2}}$ (d) $\frac{A}{2\sqrt{2}}$

30. The wave function of a particle at a certain time is

$$\psi(x) = \frac{A}{\sqrt{x^2 + a^2}} e^{ikx} \quad [a,k \text{ are positive real constants}]$$

The real value of A such that $\psi(x)$ is normalized, is

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

PART B: Multiple Select Questions (MSQ)

(Q.31 to Q. 40: 2 Marks each)

31. Suppose A_n be the area enclosed by the n^{th} orbit in a hydrogen atom. The graph of $\ln\left(\frac{A_n}{A_1}\right)$ against $\ln(n)$

(a) will pass through the origin
(b) will be a straight line with slope 4
(c) will be a monotonically increasing nonlinear curve
(d) will be a monotonically decreasing nonlinear curve

32. A particle in the infinite square well $V(x) = \begin{cases} 0 & 0 < x < a \\ \infty & \text{otherwise} \end{cases}$ is prepared in a state with the wavefunction

$$\psi(x) = \begin{cases} A\sin^3\left(\frac{\pi x}{a}\right) & 0 < x < a \\ 0 & \text{otherwise} \end{cases}$$

Which of the following statements is/are **CORRECT**?
(a) The particle will be either in the ground state or in the second excited state of the well.
(b) The probability of finding the particle in the ground state of the well, will be 0.9.
(c) The probability of finding the particle in the second excited state of the well, will be 0.4.
(d) The energy of the particle in the given state will be $0.225\frac{h^2}{ma^2}$.

33. The ortho-normalized wave functions ψ_1 and ψ_2 correspond to the ground state and the first excited state of a particle in a one-dimensional potential. You are given the information that the operator $\hat{A}$ acts on the wave function as $\hat{A}\psi_1 = \psi_2$ and $\hat{A}\psi_2 = \psi_1$. Which of the following statements is/are **CORRECT**?

(a) The expectation value of A for the state $\psi = (3\psi_1 + 4\psi_2)/5$ is 0.96.

(b) The expectation value of A for the state $\psi = (3\psi_1 + 4\psi_2)/5$ is 0.75.

(c) Both ψ_1 and ψ_2 are eigenfunctions of $\hat{A}^2$.

(d) Neither of ψ_1 and ψ_2 are eigenfunctions of $\hat{A}^2$.

34. Consider a quantum particle of mass m and energy E moving under the following 1-D potential:

$$V(x) = \begin{cases} \infty & \text{for } x \le 0 \\ -V_0 & \text{for } 0 < x < L \\ 0 & \text{for } x \ge L \end{cases}$$

Which of the following statements is/are **CORRECT**?

(a) The particle will be in a bound state for $E > -V_0$

(b) The particle has oscillatory wave function in second region and decaying wave function in the third region.

(c) The particle will be in a bound state for $-V_0 < E < 0$.

(d) The particle has decaying wave function in second region and oscillatory wave function in the third region.

35. Two events *A* and *B* occur at places separated by $2\times10^6\,km$ and at time interval 10 sec between them. Which of the following statements is/are **CORRECT**?

(a) The velocity of the frame in which these events occur at the same place, is 0.5*c*.

(b) The velocity of the frame in which these events occur at the same place, is 0.66*c*.

(c) The time interval between the events in the above mentioned frame, is 4.4 sec.

(d) The time interval between the events in the above mentioned frame, is 3.7 sec.

36. Suppose ψ_{nlm} be the eigenfunction of the Hamiltonian operator of the hydrogen atom where n, l, m are principal, orbital and magnetic quantum number respectively. Which of the following wavefunctions is/are an eigenfunction of above mentioned Hamiltonian operator? (a,b,c are constants)

(a) $a\psi_{320} + b\psi_{321} + c\psi_{32-2}$ (b) $a\psi_{421} + b\psi_{420} + c\psi_{410}$

(c) $a\psi_{211} + b\psi_{311} + c\psi_{410}$ (d) $a\psi_{322} + b\psi_{320} + c\psi_{310}$

37. Consider a particle of mass *m* is moving under the following 2-D potential:

$$V(x, y) = \frac{1}{2}m\omega^2\left(x^2 + 9y^2\right)$$

Which of the following statements is/are **CORRECT**?

(a) The energy eigenvalues of the particle is given by $(n+2)\hbar\omega$.

(b) The degeneracy of the third excited state is 2.

(c) The energy of the fourth excited state is $6\hbar\omega$.

(d) The wave function of the third excited state will be $y\exp\left[-\frac{m\omega}{2\hbar}\left(x^2 + 3y^2\right)\right]$.

38. A rod is moving with a speed of 0.4*c* along its length in the positive *x*-direction and a particle is moving with a speed 0.8*c*. along negative *x*-direction. Both speeds are measured in the in-ertial *S* frame. The length of the rod measured in the *S* frame is 3.6 m. Which of the following statements is/are **CORRECT**?

(a) Relative velocity of the rod in the rest frame of the particle, is 0.91*c*.

(b) Proper length of the rod is 4.22 *m*.

(c) Length of the rod in the rest frame of the particle, is 1.64 *m*.

(d) Time taken for the particle to cross the rod in the *S* frame, is approximately 10 *ns*.

39. The wave function of a particle in a deep square well potential extending from $x = 0$ to $x = L$, is

$$\psi(x) = \sqrt{30}\,\frac{x(x-L)}{L^i}$$

Which of the following statements is/are **CORRECT**?

(a) The value of *i* will be 1/2. (b) The value of *i* will be 5/2.

(c) The expectation value of position of the particle is *L/4*.

(d) The expectation value of position of the particle is *L/2*.

40. A set of five possible wave functions is given, where L is a positive real number.

(i) $\psi_1(x) = Ae^{-x}$ for all x (ii) $\psi_2(x) = A\cos x$ for all x

(iii) $\psi_3(x) = \begin{cases} Ae^x & 0 \le x \le L \\ 0 & \text{otherwise} \end{cases}$ (iv) $\psi_4(x) = \begin{cases} A & -L \le x \le L \\ 0 & \text{otherwise} \end{cases}$

(v) $\psi_5(x) = \begin{cases} Ax & x \ge L \\ 0 & \text{otherwise} \end{cases}$

Which of the five possible wave functions is/are normalizable?

(a) $\psi_2(x)$ (b) $\psi_3(x)$ (c) $\psi_4(x)$ (d) $\psi_5(x)$

PART C: Numerical Answer Type (NAT) Questions

(Q. 41 to Q.50: 1 marks each)

41. The degenaracy of the $n = 3$ level for an electron, moving in a two dimensional isotropic harmonic oscillator will be .... (Your answer should be **an integer**)

42. A muon is moving with a velocity 0.95*c* w.r.t laboratory frame. Assume the mean life of a muon to be $2\,\mu s$, the life time of the muon measured in the laboratory frame will be (in the units of μs) .... (Your answer should be upto **one decimal** place)

43. Positronium atom is a hydrogen-like atom that consists of a positron and an electron. The wavelength of the first Balmer line for positronium is (Given: Wavelength of the first Balmer line for hydrogen is 6563 A^0) (in the units of $\boldsymbol{A^0}$) .... (Your answer should be **an integer**)

44. One β particle moves along east direction with a velocity of 0.95*c*, while a second β particle moves along west direction with a velocity 0.85*c*. The realtive velocity between the β particles is approximately (in the units of ***c***) .... (Your answer should be upto **three decimal** places)

45. The Q-value of the following reaction:

$$ {}_1^2H + {}_1^2H \rightarrow {}_1^3H + {}_1^1H $$

is (in the units of **MeV**) .... (Your answer should be **an integer**)

46. A proton of energy 1 MeV is scattererd through 180^0 by a fixed gold nucleus. The distance of closest approach is (in the units of ***fm***) .... (Your answer should be **an integer**)

47. The difference of energy between $n = 2$ and $n = 1$ level of a particle in a one dimensional infinite potential well is 6 units of energy. In the same units of energy, the difference of energy between $n = 3$ and $n = 2$ level, is .... (Your answer should be **an integer**)

48. The atoms in a nickel crystal vibrate as harmonic oscillators with an angular frequency of 2.3×10^{13} rad/s. The mass of a nickel atom is 9.75×10^{-26} kg. The spacing of the vibrational energy levels of nickel is closest to (in the units of ***eV***) .... (Your answer should be upto **three decimal** places)

49. Particles of energy 9 eV are sent towards a potential step of 5 eV high. The percentage of the particles will be reflected is .... (Your answer should be **an integer**)

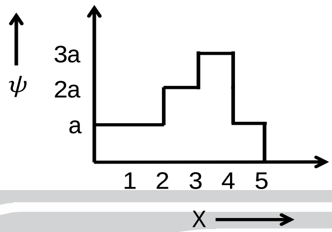
50. X-rays of wavelength 10 pm are scattered from the target. The maximum wavelength that are present in the scattered X-rays (in the units of ***pm***) is .... (Your answer should be upto **one decimal** place)

(Q. 51 to Q.60: 2 marks each)

51. The electric field associated with a monochromatic beam of light becomes zero 1.4×10^{15} times per second. If this light falls on a metal surface having work function 2.2 eV, the maximum kinetic energy of the emitted photoelectrons will be (in the units of **eV**) .... (Your answer should be upto **two decimal** places)

52. A light beam of wavelength 400 nm is incident on a metal plate of work function 2.20 eV. A particular electron absorbs a photon and makes collisions before coming out of the metal. Assuming 10% of the energy excess of the average energy of other electrons is lost to the metal in each collision. The maximum number of collisions the electron can suffer and still be able to come out of the metal, will be
.... (Your answer should be **an integer**)

53. The wave function of a particle constrained to move in one dimension is shown in the graph below:



The probability that the particle will be found between x = 2 and x = 4, will be
.... (Your answer should be upto **two decimal** places)

54. The ratio of the energy of the first excited state and ground state of a particle, in a 3-D rectangular box of sides a, a and $\frac{a}{2}$ is
.... (Your answer should be upto **one decimal** place)

55. The recentlly discovered Higgs Boson at the LHC experiment has a decay mode into a photon and Z boson. If the rest masses of the Higgs boson and Z boson are 125 GeV/c^2 and 90 GeV/c^2 respectively and the decaying Higgs boson is at rest, then the energy of the photon will be (in the units of GeV)
.... (Your answer should be **an integer**)

56. A neutron star has a density equal to that of the nuclear matter $\left(\approx 2.4\times10^{17}\,kg/m^3\right)$. Assuming the star to be spherical, the radius of the neutron star will be (in the units of ***km***)
(Given: Mass of the neutron star is $4\times10^{30}\,kg$)
.... (Your answer should be upto **one decimal** place)

57. Four particles each of mass m, are confined inside a 2-D square box of side a. If each state obtained from the solution of the Schrodinger equation is occupied by only one particle, then the ground state energy of the system will be (in the units of $\frac{h^2}{mL^2}$)
.... (Your answer should be upto **one decimal** place)

58. The binding energy of a deutron is 2.2 MeV. In the reaction $d + d \rightarrow \alpha$, 23.6 MeV is realeased. The binding energy per nucleon of an α – particle is equal to (in the units of ***eV)***
.... (Your answer should be **an integer**)

59. An electron is bound in an infinite square-well potential on the x- axis. The width of the well is L and the well extends from $x = 0$ nm to $x = 3.3$ nm. In a given state, the normalized wave function of the electron is given by:

$$\psi(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{2\pi x}{L}\right)$$

The probability per nm of finding the electron at $x = 1.65\ nm$, is closest to ....

60. A particle of mass 'm' is moving under a potential of the form

$$V(x) = \begin{cases} \frac{1}{2} m\omega^2 x^2 & for\ x > 0 \\ \infty & for\ x \le 0 \end{cases}$$

Let the wave function of the particle corresponding to the above potential is

$$\psi(x) = -\frac{1}{\sqrt{5}}\psi_0 + \frac{2}{\sqrt{5}}\psi_1$$

where ψ_0 and ψ_1 are eigen functions of the ground and first excited state respectively. The expectation value of energy in the state $\psi(x)$ is (in units of $\hbar\omega$)

.... (Your answer should be upto **one decimal** place)

Space for Rough Work

IIT-JAM PHYSICS-PH

TEST SERIES-4

Date : 12-01-2016

ANSWER KEY

ANSWER KEY

PART A: Multiple Choice Questions (MCQ)

1. (d)	2. (d)	3. (a)	4. (b)	5. (b)	6. (a)
7. (b)	8. (d)	9. (b)	10. (c)	11. (b)	12. (a)
13. (d)	14. (b)	15. (b)	16. (c)	17. (a)	18. (c)
19. (a)	20. (a)	21. (c)	22. (c)	23. (a)	24. (d)
25. (a)	26. (b)	27. (d)	28. (c)	29. (c)	30. (b)

PART B: Multiple Select Questions (MSQ)

31. (a,b)	32. (a,b,d)	33. (a,c)	34. (b,c)	35. (b,d)	36. (a,b,d)
37. (a,b,c,d)	38. (a,c,d)	39. (b,d)	40. (b,c)		

PART C: Numerical Answer Type (NAT) Questions

41. (8)	42. (6.3 to 6.5)	43. (13126)	44. (0.995 to 0.997)	45. (4)
46. (113 to 116)	47. (10)	48. (0.013 to 0.017)	49. (4)	50. (14.8 to 15)
51. (0.68 to 0.70)	52. (3)	53. (0.80 to 0.82)	54. (1.5)	55. (30)
56. (15.7 to 15.9)	57. (2.5)	58. (7)	59. (0)	60. (3.1)