K.S ACADEMY, SALEM

PG TRB, UG TRB, POLYTECHNIC, ENG-TRB, AEEO TRB & TNSET

COACHING CENTRE FOR PHYSICS

unit test:Quantum Mechanics

Time:1.30Hour Marks: 80

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Answer all the question:

PART-A (2 MARKS)

1. An electron is confined in a one-dimensional potential box of width 0.1nm.The minimum momentum of electron inside the box is?

a) $0.5 \times 10^{-24}\ kgms^{-1}$ b) $13.6 \times 10^{-24}\ kgms^{-1}$

c) $6 \times 10^{-25}\ kgms^{-1}$ d) $10.27 \times 10^{-25}\ kgms^{-1}$

2. A particle is described by the wave function $\Psi(x) = Nxe^{-\lambda x}$ $x > 0$

$= 0$ $x < 0$

The normalized constant N is :

a) $2\,\lambda^{\frac{1}{2}}$ b) $2\,\lambda^{2}$ c) $2\,\lambda^{\frac{3}{2}}$ d) $\lambda^{\frac{1}{2}}$

3. Consider an electron in a one-dimensional potential box of width $1\mu m$ within rigid boundary conditions. The ground state energy of electron is _____

a)$2 \times 10^{-2}\ eV$ b) $3.7 \times 10^{-7}\ eV$

c) $2 \times 10^{-16}\ eV$ d) $2.2 \times 10^{-5}\ eV$

4. Which of following is/are the eigen states of the linear momentum operator $\hat{P}_x$.

i) Ae^{ikx} *ii)* $A(sin\,kx + cos\,kx)$

iii) $Acoskx$ iv) Ae^{-ikx}

a) i – only b) i and ii

c) ii and iii d) i and iv

5. The condition for operator $\hat{A}$ and $\hat{B}$ are Hermitian operator is

a) $\hat{A}$ and $\hat{B}$ both are identity operator b) $\hat{A}$ and $\hat{B}$ both are unitary operator

c) $\hat{A}$ and $\hat{B}$ not commute d) $\hat{A}$ and $\hat{B}$ commute

6. *The* commutator of $[L_x, r^2]$ is

a) $2i\hbar x$ b) 0 c) $-i\hbar L_x$ d) $i\hbar L_x$

7. The value of L^2 is measured as $12\hbar^2$. if L_Z measured, then what possible values can result?

a) $\frac{3}{2}\hbar,\ \frac{1}{2}\hbar,\ \hbar,\ -\frac{1}{2}\hbar,\ -\frac{3}{2}\hbar$ b) $6\hbar,\ 3\hbar,\ \hbar,\ 0, -\hbar,\ -3\hbar,\ -6\hbar$

c) $3\hbar,\ 2\hbar,\ \hbar,\ 0, -\hbar,\ -2\hbar,\ -3\hbar$ d) $\frac{11}{2}\hbar,\ \frac{9}{2}\hbar,\ \frac{7}{2}\hbar,\ \frac{5}{2}\hbar,\ \frac{3}{2}\hbar,\ \frac{1}{2}\hbar$

8. For angular momentum quantum number $J = \frac{3}{2}$, allowed values of m are $\frac{3}{2},\ \frac{1}{2},\ -\frac{1}{2},\ -\frac{3}{2}$. So, there are four basis states are possible, then the matrix elements of $J_z{}^2$ is

a) $\hbar \begin{bmatrix} \frac{3}{2} & 0 & 0 & 0 \\ 0 & \frac{1}{2} & 0 & 0 \\ 0 & 0 & \frac{-1}{2} & 0 \\ 0 & 0 & 0 & \frac{-3}{2} \end{bmatrix}$

b) $\hbar^2 \begin{bmatrix} \frac{9}{4} & 0 & 0 & 0 \\ 0 & \frac{1}{4} & 0 & 0 \\ 0 & 0 & \frac{1}{4} & 0 \\ 0 & 0 & 0 & \frac{9}{4} \end{bmatrix}$

c) $\hbar^2 \begin{bmatrix} 3 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -3 \end{bmatrix}$

d) $\hbar \begin{bmatrix} \frac{3}{4} & 0 & 0 & 0 \\ 0 & \frac{1}{4} & 0 & 0 \\ 0 & 0 & \frac{1}{4} & 0 \\ 0 & 0 & 0 & \frac{3}{4} \end{bmatrix}$

9. Read the following statements and choose incorrect one.

a) The degenerate perturbation theory provides the study of the n = 2 states of a hydrogen atom inside an electric field.

b) In a hydrogen atom all four n = 2 states have the same energy.

c) The lifting of degeneracy when the atom is placed in an electric filed is called the Stark effect

d) Pattern of Stark spliting of hydrogen atom in n = 2 state shows that fourfold degeneracy is completely lifted by the perturbation

10. The wavelength of a thermal neutron of speed v that corresponds to room temperature T = 300 K is.

a) 0.55 Å b) 1.45 Å c) 2.55 Å d) 2 Å

11. Which of the following is/are not a properties of a valid wavefunction (ψ)?

1) ψ must single valued 2) ψ must continuous

3) ψ must differentiable 4) ψ must square integrable

a) i and iv b) i, ii and iv

c) i, ii, iii, & iv d) none of the above

12. Justify which of the following wave function defined for interval $0 \leq x < \infty$. could be a valid wavefunction or not.

(P) $\Psi(x) = x$ (Q) $\Psi(x) = e^{-x^2}$

a) P - valid wave function, Q - valid wave function

b) P - valid wave function, Q – not a valid wave function

c) P – not a valid wave function, Q - valid wave function

d) P – not a valid wave function, Q – not a valid wave function

13. The wave function for a particle confined to a region $0 \leq x \leq a$ in the ground state was found to be

$\psi(x) = \sqrt{\frac{2}{a}} \sin\frac{\pi x}{a}$ The probability that the particle is found in the interval $\frac{a}{2} \leq x \leq \frac{3a}{4}$ is

a) $\frac{\pi+2}{4\pi}$ b) $\frac{\pi+4}{2\pi}$ c) $\frac{\pi+2}{3\pi}$ d) $\frac{\pi+4}{6\pi}$

14. The sampling property of the Dirac Delta function is represented as

a) $\int_{-\infty}^{\infty} \delta(x-a) f(x)\, dx = f(0)$ b) $f(x)\delta(x-a) = f(a)\delta(x-a)$

c) $\int_{-\infty}^{\infty} \delta(x) f(x)\, dx = f(0)$ d) $\delta(ax) = \frac{1}{|a|}\delta(x)$

15. If $|\psi>, |\varphi>$ be two vectors belonging to a complex vector space then $<\psi|\varphi> = 0$ say that

a) the vectors satisfies Cauchy-Schwartz Inequality

b) the vectors are normal

c) they are Orthonormal Vectors

d) the vectors are orthogonal

16. The commutator $[H, a] =$

a) $-\hbar\omega a$ b) $\hbar\omega a$ † c) -1 d) 1

17. The commutator $[J_Z, J_+] =$?

a) $2i\hbar J_x$ b) $2i\hbar J_+$ c) $-2i\hbar J_+$ d) $\hbar J_+$

18. The state of a hydrogen atoms is $\varphi = \frac{1}{\sqrt{2}}\Psi_{1s} + A\Psi_{2p} + \frac{1}{\sqrt{8}}\Psi_{3s}$, then the value of A for which that the state is normalized is

a) $\sqrt{\frac{3}{8}}$ b) $\sqrt{\frac{1}{3}}$

c) $\sqrt{\frac{3}{2}}$ d) $\frac{\sqrt{3}}{4}$

19. The angular momentum operator acts on a state $\psi(r,\theta,\varphi)$ as

a) $L^2\psi = \hbar^2\, l(l+1)\psi$ b) $L\psi = h\, l(l+1)\psi$

c) $L\psi = \hbar^2 l(l+1)\psi$ d) $L\psi = \hbar^2 l(l-1)\psi$

Choose the correct option about following statements

A) The energy levels of the one-dimensional harmonic oscillator are not equally spaced

B) The energy levels of the one-dimensional harmonic oscillator are not degenerate

a) both are correct b) both are incorrect

c) A is correct , B is incorrect d) A is incorrect , B is correct

20. The scattering of a black disk at high energies the ratio of Classical total cross section to the quantum total cross section is

a) 1/2 b) 2 c) 3/2 d) 4/3

ANSWER KEY WITH EXPLANATION ON THE LAST PAGE

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Contact: 9047767620, 9042976707 & 8148891005

2018 Batch Schedule

- The class begins promptly at 9:45 a.m. and ends at 4:30 p.m.
- Students are expected to attend a minimum of six months.
- The results will be available immediately after the test.

Month/Week	Topics Covered	Total Hours
September / Week-2 & 3	Maxwell Boltzmann statistics - Bose-Einstein statistics - Phonon gas – Black body radiation – Thermionic emission	14
September / Week-4	Fermy-Dirac statistics – phase transition - phase space - ensembles- equipartition of energy.	7
October / Week-1	Statistical Mechanics- test & Gauss law – Poisson's equation – Laplace equation - boundry value problem - dielectric media –	7
October / Week-2 & 3	Vector – B and H in a magnetic material – Maxwell's equations- Poynting theorem – Relativistic Mechanics	14
October / Week-4	Electromagnetic theory & Relativistic Mechanics test & Vector Fields- Stokes	7

	theorem and Gauss theorem-	
November / Week 1	Matrix theory- orthogonal. Hermitian and symmetric matrices. Special functions- Gamma and Beta functions	7
November / Week 2	Unit -I test & Semi empirical mass formula- Alpha decay – B decay -Liquid drop model – Shell model – Collective models.	7
November / Week 3	Nuclear Instrumentation - Nuclear reactors – Neutron cross section – Fission product	7
November / Week 4	Nuclear physics test & Digital electronics- number system - Flip-flops- counters - registers	7
December / Week 1 & 2	Operational amplifier- Sample and hold circuits – Oscillator- multivibrators – Clipping and clamping circuits	14
December / Week 3	Electronics part-1 test & Lagrangian equation of motion – Hamiltonian equation- principle of least action	7
December / Week 4	Theory of small oscillations- Rigid bodies	7
January / Week 1	Classical mechanics test & Probability and Theory of errors- Principle of least squares – Curve fitting	7
January / Week 2	Group theory	7
January / Week 3	Unit 2 test & Rotation spectra – Vibration spectra- Raman Spectra	7
January / Week 4	Electronic state of diatomic molecules – Frank–Condon principle- NMR	7
February / Week 1	Spectroscopy test & Microprocessor	7
February / Week 2	Microwave generation – Klystron – Magnetron – Travelling wave tubes- Antenna	7
February / Week 3	Electronics part-2 test & density of states in one, two and three dimensions – Electrical and Thermal conductivities -Bloch theorem - Krong-Penny mudel –Brillouin zones	7

February / Week 4	Thermal Properties of solids- Magnetic properties of materials- superconductivity	7
March / Week 1 & 2	Solid state physics test & Schrodinger's wave equation – Free particle – Particle in a potential well - Wave packet – Uncertainty principle – Linear Harmonic oscillator – angular momentum	14
March / Week 3	Peturbation theory - scattering cross section – Born approximation – Partial wave analysis- Relativistic wave equations – Klein – Gordon equations – Dirac equation	7
March / Week 4	Quantum mechanics test & and two half test	12
April, May	Full test-1,2,3,4,5,6,7,8,9, 10	48

NEW BATCH-3 DEMO CLASS ON 16.09.2018 SUNDAY

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ANSWER KEY -QUANTUM MECHANICS

TWO MARKS

Q1. Key word : minimum momentum

So $\Delta x \, \Delta p_x = \frac{\hbar}{2}$

$\Delta p_x = \frac{1.05 \times 10^{-34}}{2 \times \Delta x}$

$= \frac{1.05 \times 10^{-34}}{2 \times 1 \times 10^{-10}}$

$= 0.5 \times 10^{-24}$ kgms +1

opt : (a)

Q2 $\psi(x) = N x e^{-\lambda x}$

Normalisation constant

$\int \psi^* \psi \, dx = 1$

$N^2 \int_0^\infty x^2 e^{-2\lambda x} \, dx = 1$

$N^2 \frac{2!}{(2\lambda)^3} = 1$

$N = 2\lambda^{3/2}$

opt : (c)

Q3. Key word : width = 1 Å

$E_n = \frac{n^2 \hbar^2 \pi^2}{2mL^2}$ (KS spr short cut)

use short cut we get

Ans: 3.7×10^{-7} eV.

opt : (b)

Q.4

Eigen state of linear momentum operator -

$p_x = -i\hbar \frac{d}{dx}$

(i) $A e^{ikx}$

$= -i\hbar \frac{d}{dx}(A e^{ikx})$

$= \hbar k A e^{ikx}$

So it is an eigen state.

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ANSWER KEY -QUANTUM MECHANICS

(iv) $A e^{-ikx}$

operate by momentum operator.

$-i\hbar \frac{d}{dx}(A e^{-ikx})$

$= -\hbar k A e^{-ikx}$ ✓

Ans: opt (d)

Q5 Ans: d

Q6 use short cut (KS sir)

Ans: b

Q7 Eigen values of L^2 is

$L^2 = l(l+1)\hbar^2$

$12\hbar^2 = l(l+1)\hbar^2$

$\boxed{l = 3}$

L_z → can takes values from $-l\hbar$ to $l\hbar$

Ans: c

Q.8. Use angular momentum matrix formula.

Ans: b

Q.9 Ans: d.

Q.10 Ans: b

Q.11 Key word: not a properties of ψ.

Ans: d

Q.12 ψ must be single valued so.

(P) $\psi(x) = x$

If $x \to \infty$ $\psi \to \infty$

Hence not a valid wave function.

(Q) $\psi(x) = e^{-x^2}$

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ANSWER KEY -QUANTUM MECHANICS

If $x = \infty$

$e^{-x^2} = e^{-\infty} = 1$

If $x = -\infty$

$e^{-x^2} = e^{-\infty} = 1$

so valid wave function.

ANS: C

Q.13 KS Academy

Use short cut method.

we get ans: $\frac{1}{4} + \frac{1}{2\pi}$

(or) $\frac{\pi + 2}{4\pi}$

ANS: a

Q.14 ANS: C

Q.15 ANS: d

Q.16 $[H, a] = ?$

use short cut (KS sir)

ANS: a

Short cut method.

Q.17 ANS: d

Q.18 If ϕ is normalised then

$\int \phi^* \phi \, dx = 1$

$\frac{1}{2} + A^2 + \frac{1}{8} = 1$

$A^2 = \frac{3}{8}$ $A = \sqrt{\frac{3}{8}}$

ANS: a

Q.19 ANS: a

Q.19(a) ANS: d

Q.20. $\frac{\sigma_{classical}}{\sigma_{quantum}} = \frac{\pi d^2}{2\pi d^2}$

$= \frac{1}{2}$

ANS: a

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ANSWER KEY -QUANTUM MECHANICS

ONE MARK

Q.21 b
Q.22 d
Q.23 b
Q.24 c
Q.25 a
26. a
27. a
28. d
29 c
30 a (use short cut)
31. b
32 b -use short cut
33 c
34 c
35 c
36. d
37. b
38. a
39. c
40. b
41. a
42. a
43: a
44. b
45. c
46. c
47. Keyword incident current density
Ans: b
48. b
49. use KS Academy Short cut get the
Ans: $\frac{\hbar^2\pi^2}{16mL^2}$
Ans: c
50. a
51. d
52. -use KS Academy Short cut method
Ans: b.
53. b
54. b
55. b
56. c
57. use Short KS Sir cut
Ans: c.
58. $\langle r\rangle = \frac{a_0}{2}[3n^2 - \ell(\ell+1)]$
$= 69_0$
opt: a
59. a
60. d.