Seat No. : ______________

DA-112

December-2018

M.Sc., Sem.-I

401 : Physics

(Quantum Mechanics-I and Mathematical Physics-I)

(New and Old Course)

Time : 2:30 Hours] **[Max. Marks : 70**

1. (A) (i) Discuss perturbation theory for degenerate states. Show that first order correction to energy can be obtained by diagonalizing $m \times n$ matrix. **7**

(ii) Explain stark effect for first excited state of hydrogen atom. Find first order correction to the energy and show that degeneracy is not completely remove when H-atom is placed in a uniform electric field.

[Hint : Consider matrix elements of perturbed Hamiltonian for which $l = l' = 0$, $l = l' = 1$ and $m \neq m'$ are zero]. **7**

OR

(i) Show that $W \geq E_0$ and $[\langle H^2 \rangle_\psi - W^2]^{1/2} \geq (W - E_0)$. **7**

(ii) Find out minimum energy of the He-atom using variation method. **7**

(B) Answer any **four** questions : **4**

(1) Show that for the electric dipole when placed in the uniform electric field of intensity E, the term $\frac{1}{2}\ \alpha\ E^2$ has unit of energy. Here, α represents polarizability.

(2) Show that $\nabla_{11} = \nabla_{22}$.

(3) Write degenerate states for $n = 4$.

(4) What will be the scalar product corresponding to the eigen state for energy $+ 3eEa$ and $-3eEa$?

(5) When diploe moment is aligned to uniform electric field, what will be its energy eigen value ?

(6) What is the numerical value of effective valency of the atom ?

2. (A) (i) Write an equation of propagator $G(\vec{r}, \vec{r}\,' ; t, 0)$. Find out differential equations for propagator and retarded propagator. **7**

(ii) Show that in Sudden approximation transition probability is directly proportional to time T and matrix element of $H_0 - H$ between final and initial states. **7**

OR

(i) Obtain Bohr-Sommerfeld quantization condition. **7**

(ii) Using Bohr-Sommerfeld quantization condition show that energy of simple harmonic oscillator is given by $E = \hbar\omega\left(n + \frac{1}{2}\right)$. **7**

(B) Answer any **four** questions. **4**

(1) Define Heaviside function.

(2) What will be the dimension of $S(x)$ in equation $u(x) = A(x)\, e^{\frac{iS(x)}{\hbar}}$?

(3) In WKB approximation solution of the Schrödinger equation is expanded in power ________. Complete the statement.

(4) In non-classical region, kinetic energy of particle is negative. True or false

(5) If $V(x)$ is slowly varying function, then what will be $\int P(x)dx$?

(6) What do you mean by classical turning point ?

3. (A) Write the following :

Prove that Laplace transform :

(i) $L\{\sin kt\} = \frac{k}{s^2 + k^2}$ and

$L\{t^n\} = \frac{n!}{s^{n+1}}$, $s > 0$, $n > -1$ **7**

(ii) Evaluate the inverse Laplace transform, $L^{-1}\left\{\frac{s^2}{(s^2 + a^2)(s^2 + b^2)}\right\}$. **7**

OR

(i) The motion of a body falling in a resisting medium is given by **7**

$m\frac{d^2x(t)}{dt^2} = mg - b\frac{dx(t)}{dt}$, when the retarding force is proportional to the velocity. Find $x(t)$ and $x'(t)$ for the initial conditions $x(0) = x'(0) = 0$. **7**

(ii) Using Laplace transforms, solve the set of equations :

$y' - 2y + z = 0$, and

$z' - y - 2z = 0$, with initial conditions: $y(+0) = 1$, $z(+0) = 0$.

Given : $L\{e^{-at} \sin bt\} = b/[(s+a)^2 + b^2]$, and

$L\{e^{-at} \cos bt\} = (s+a)/[(s+a)^2+b^2]$

(B) Answer the following : (Any **Three** out of **Five**) **3**

(1) Write the equation representing linearity operation for Laplace transform.

(2) Give the definition of Heaviside unit step function.

(3) Write an expression for the Laplace transform of third derivative of F(t).

(4) What is the Laplace transform of Dirac delta function

$L\{\delta(t-t_0)\} = \ldots\ldots\ldots t_0 \geq 0$?

(5) For $s > 0, L\{1\} = \ldots\ldots$.

4. (A) Write the answer of the following :

(i) Prove that every tensor of second rank be resolved into anti-symmetric and symmetric part. **7**

(ii) Give definition of a group. Explain four properties of a group with relevant examples. Give a group table of order three with different elements A, B, E. **7**

OR

(i) If A_{ij}, B_{ij}, C_{ij} and D_{ij} tensors of second rank and same type, then prove that $A_{ij} - B_{ij} = D_{ij}$ and $A_{ij} + B_{ij} = C_{ij}$. **7**

(ii) Define a class. Discuss four properties of a class with relevant examples. **7**

What do you understand by product of classes ?

(B) Answer any **three** short questions : **3**

1. List the difference between homomorphism and isomorphism.
2. What do you understand by ‘conjugate of subgroups’ ?
3. Give an example of second rank tensor.
4. Triad has ____ components.
5. ‘Tensors can be multiplied by other tensors to form new tensors’ This sentence is __________.s (correct, wrong)