Seat No. : _______________

NO-114

December-2015

M.Sc., Sem.-I

401 : Physics

(Quantum Mechanics-1 & Mathematical Physics)

Time : 3 Hours] **[Max. Marks : 70**

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

OR

Explain : variation method. Show that $(W - E_0) \leq \left[\langle H^2\rangle_\psi - W^2\right]^{1/2}$.

(b) Discuss Stark effect for the first excited state of hydrogen atom. Obtain eigen values and eigen vectors. Explain how degeneracy is not completely removed. **7**

Given : $|U_{200}\rangle = \left[\frac{1}{32\pi a^3}\right]^{1/2} \left[2 - \frac{r}{a}\right] \exp\left(-\frac{r}{2a}\right)$ and

$$|U_{210}\rangle = \left[\frac{1}{32\pi a^3}\right]^{1/2} \left[\frac{r}{a}\right] \exp\left(-\frac{r}{2a}\right) \cos\theta.$$

OR

Set-up Hamiltonian for Hydrogen molecule. Solving Schrodinger equation, obtain energies of symmetric and anti-symmetric states.

2. (a) What is propagator ? Write differential equation for propagator and obtain propagator for free particle. **7**

OR

Obtain Bohr-Sommerfeld quantization condition and find energy of simple harmonic oscillator.

(b) Discuss sudden approximation and obtain expression for transition probability. **7**

OR

Obtain solution of the time dependent Schrodinger equation. What do you mean by retarded propagator ? Obtain equation for propagator.

3. (a) Obtain Laplace transform of

$f(t) = t^n; t > 0; n > -1$ **7**

OR

Obtain Laplace transform of

(i) $f(t) = t \sin at; t > 0; a = \text{constant}$.

(ii) $f(t) = t \cos at; t > 0; a = \text{constant}$

(b) Describe the method of solving the differential equation by Laplace transform. **7**

OR

A particle of mass 3 g moves on the x-axis and is attracted towards a fixed point with a force whose numerical value is 12 x. Assuming that the particle is initially at rest at $x = 5$, determine the position of particle at any time t,

(i) when there is no other force.

(ii) when there is a damping force whose numerical value is 6 times the instantaneous velocity.

4. (a) Define a class and subgroup. Write four postulates of subgroup. Discuss two interesting results involving classes. **7**

OR

What do you understand by 'closer property of the group' ? Define left and right coset and discuss meaning of disjoint set.

(b) Show that :

(i) $A_{ik} + B_{ik} = C_{ik}$

(ii) $A_{ik} - B_{ik} = D_{ik}$

Where A_{ik}, B_{ik}, C_{ik} and D_{ik} are Tensors of same rank. **7**

OR

Define a 'tensor' and show that,

$$V^2 = V.V = \Sigma_i \Sigma_j g_{ij} V_i V_j$$

5. Answer the following questions : **14**

(1) Define Heaviside unit function.

(2) What is exchange integral ?

(3) In WKB method expansion of wave function is in power series of _____.

(4) Show that $\Delta_{I,II} = \Delta_{II,I}$.

(5) Write normalized eigen-states for the energy $W^{(1)} = \pm 3eEa$.

(6) If wave function for free particle is $\psi = e^{-\alpha r}$ with α = constant, find $w \equiv \langle H \rangle_{\psi}$.

(7) What will be perturbed Hamiltonian when Helium-atom is placed in the uniform electric field of intensity E ?

(8) If S_{ij} is a symmetric tensor and A_{ij} is an anti-symmetric tensor, what is product of $S_{ij}.A_{ij}$?

(a) a tensor of mixed symmetry
(b) an anti-symmetric tensor
(c) a symmetric tensor
(d) zero

(9) If A^{μ} and B_{v} are components of contravariant and covariant tensors, what is the nature of the quantity $A^{\mu}B_{v}$?

(a) zero
(b) an invariant
(c) a covariant
(d) a mixed tensor of rank 2

(10) What is 'quotient group' ?

(11) Show that A (B.C) = (A.B) C

(12) Which one of the following statement is true for Laplace transformation ?

(a) $L(y^n) = p^n L(y) - p^{n-1}y_0 - p^{n-2} y_0' - p^{n-3}y_0'' - \ldots\ldots - y_0^{n-1}$

(b) $L(y^n) = p^n L(y) - p^{n-1}y_0 - p^{n-2} y_0' - p^{n-3}y_0'' - \ldots\ldots - y_0^{n}$

(c) $L(y^n) = p^n L(y) - p^{n-1}y_0 + p^{n-2} y_0' - p^{n-3}y_0'' + \ldots\ldots + y_0^{n-1}$

(d) $L(y^n) = p^n L(y) - p^{n-1}y_0 - p^{n-2} y_0' - p^{n-3}y_0'' - \ldots\ldots - y_0^{n+1}$

(13) $L(e^{-at})$ = ______ Re(p + a) > 0.

(14) _______ is a kernel for Fourier transform.