D 132058 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, NOVEMBER 2025

(CBCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions, each question carries weightage* 1.

1. What is hyperfine splitting in hydrogen atom ?
2. Explain briefly the principle of time independent perturbation theory.
3. List the connection formulas in WKB approximation.
4. Explain briefly the variation method for excited states.
5. Discuss validity of Born approximation.
6. What do you mean by condition of detailed balancing ?
7. What are spinors ?
8. Write down Weyl equation for neutrino.

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions, each question carries weightage* 5.

9. Discuss the fine structure of hydrogen atom. Obtain the complete fine structure formula by considering the relativistic correction and spin orbit coupling.
10. Discuss the time dependent perturbation theory. Derive the transition probability for harmonic perturbation.

Turn over

11. What are Partial waves ? Obtain optical theorem.

12. Write an essay on nonrelativistic limit of an operator in Dirac theory.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions, each question carries weightage* 3.

13. Discuss stark effect in hydrogen atom.

14. Optimize the trial wave function e^{-ar} and evaluate the ground state energy of hydrogen atom.

15. What is dipole approximation? Also define electric dipole transition moment.

16. What is scattering amplitude? How is it related to scattering cross section?

17. Derive Klein Gordan equation.

18. Discuss hole theory.

19. Obtain the first order correction to the energy eigen value of an anharmonic oscillator.

(4 × 3 = 12 weightage)

D 111206 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, NOVEMBER 2024

(CBCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Why the hydrogen atom in the ground state does not show a first order stark effect ?
2. Explain briefly the variation method for excited state.
3. Briefly discuss optical theorem.
4. Explain Fermi's golden rule.
5. What do you understand by classical turning points ?
6. Distinguish between normal and anomalous Zeeman effect.
7. Explain quadratic stark effect.
8. What are negative energy states ? What are holes ?

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions.*
Each question carries weightage 5.

9. Discuss the first order time independent perturbation theory for non-degenerate stationary state. Obtain the corrected eigen value and eigen function.
10. What are Einstein's transition probabilities ? Outline the way in which absorption and emission of radiation is explained in quantum mechanics. Explain how the selection rules follow naturally.

Turn over

11. What is scattering cross section? Obtain an expression for scattering cross section using Green's function method.

12. Write an essay on nonrelativistic limit of an operator in Dirac theory.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

13. Work out the splitting of the $^1P \rightarrow {}^1S$ transition of an atom placed in a magnetic field B along the z axis.

14. A particle of mass m moving in the potential $V(z) = mgz$, $z > 0$ and $V(z) =$ infinity, $z < 0$. Optimize the trial wave function $\phi = Az\, e^{-ax}$, where a is the variable parameter and estimate the ground state energy of the system.

15. Explain the Dirac particle in an electromagnetic field.

16. Write a note on Born approximation.

17. Explain how the Klein Gordan equation leads to positive and negative probability density values.

18. Obtain Dyson Series. Define transition probability.

19. Obtain the first order correction to the energy eigen value of an anharmonic oscillator.

(4 × 3 = 12 weightage)

D 51328 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, NOVEMBER 2023

(CBCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions, each question carries weightage* 1.

1. The WKB is valid for systems in which the potential is slowly varying. Why ?
2. Briefly discuss hyperfine splitting.
3. Briefly explain Rayleigh - Ritz method.
4. What is spin orbit interaction ?
5. The result of variation method always gives an upper limit for the ground state energy of the system. Why ?
6. What are partial waves ?
7. Discuss the validity of Born approximation.
8. Define helicity operator. What are the eigen values of helicity operator ?

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions, each question carries weightage* 5.

9. Write an essay on Zeeman effect.
10. Explain WKB approximation. Obtain connection formulae.

Turn over

11. Distinguish between spontaneous and stimulated emission. Prove that spontaneous emission is completely a quantum effect.

12. Derive the Dirac equation for a free particle. Find out the Dirac matrices. Obtain the Dirac equation in covariant form.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions, each question carries weightage* 3.

13. Write a note on two fold degeneracy using degenerate perturbation theory.

14. Estimate the ground state energy of a one dimensional harmonic oscillator of mass m and angular frequency ω using a Gaussian trial function.

15. Obtain the transition probability for a constant perturbation.

16. Write a note on stark effect in hydrogen atom.

17. Obtain the Hamiltonian operator for a charged particle in an electromagnetic field.

18. Explain how Klein Gordon equation leads to positive and negative probability density values.

19. What is scattering amplitude ? How is it related to scattering cross section ?

(4 × 3 = 12 weightage)

D 31197 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, NOVEMBER 2022

(CBCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Explain the consequence of linear stark effect in hydrogen atom.
2. What is the principle of non-degenerate time independent perturbation theory ?
3. What are the limitations of WKB approximation ?
4. Describe the principle of Variational method.
5. Briefly discuss detailed balancing. Explain why the intensity of stimulated emission between two atomic levels is much less than that of stimulated absorption.
6. What is differential scattering cross section ? How is it related to number of particles scattered ?
7. What is Weyl equation ? Give its significance.
8. Give Klein Gordon equation. Give its features.

(8 × 1 = 8 weightage)

Section B

Answer any **two** *questions.*
Each question carries weightage 5.

9. Discuss time independent perturbation theory and apply it to find the shift in energy levels of an atom when placed in weak and strong magnetic fields.
10. Discuss WKB approximation with respect to tunnelling a potential barrier and hence explain alpha decay from the nucleus.

Turn over

11. Discuss scattering by a central potential and hence state and prove optical theorem.

12. Find the nonrelativistic limit of Dirac equation and hence show that the positive energy Dirac particles are electrons.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

13. Apply stationary perturbation theory to find the energy levels of Anharmonic oscillator.

14. Using Variational principle find the ground state energy of one dimensional harmonic oscillator.

15. Give an account of electric dipole approximation and obtain expression for transition probability for unit time.

16. Apply Time dependent perturbation theory in the case of Harmonic perturbation to find the transition probabilities.

17. Show that the scattering cross section is independent of energy and scattering angle for scattering by square well potential.

18. Find the equation of continuity for the Dirac particle and hence derive the expression for conserved current from Dirac equation.

19. Show that the orbital angular momentum is not conserved for Dirac particles.

(4 × 3 = 12 weightage)

D 11688 **(Pages : 2)** **Name.....**

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, NOVEMBER 2021

(CBCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. What is the difference between the Zeeman correction to energy in weak magnetic field and in strong magnetic field ?
2. Explain why non degenerate time independent perturbation theory cannot be applied to degenerate cases.
3. Describe the principle of Variational method.
4. Describe the connection formulae for WKB approximation.
5. What is meant by Dyson's series ?
6. What is optical theorem ? What does it imply ?
7. What are the properties of Dirac matrices ?
8. What is Weyl equation ? Give its significance.

(8 × 1 = 8 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each question carries 5 *weightage.*

9. Discuss time independent degenerate perturbation theory and apply the same to explain the fine structure of the Hydrogen atom due to the relativistic correction.

10. Describe the method of WKB approximation. Apply it to find the wave function and energy inside a potential well with two vertical walls.

11. Deduce the expression for transition probability for induced emission for an atom placed in an electromagnetic field.

12. Discuss the method of partial waves with respect to the scattering by central potential. Find the total scattering cross section.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

13. Find the wave function and energy levels of anharmonic oscillator.

14. Using Variational principle find the ground state energy of one dimensional harmonic oscillator.

15. Apply Time dependent perturbation theory to find the absorption energy from the field in the case of Harmonic perturbation.

16. For scattering by square well potential show that the scattering cross section is independent of energy and scattering angle.

17. Derive the Klein Gordon equation. Find the corresponding probability density.

18. Show that the total angular momentum is a constant of motion for Dirac particles.

19. Using time independent perturbation theory find the first order correction to the energy of $n = 2$ state of hydrogen atom in the presence of electric field.

(4 × 3 = 12 weightage)

D 91051 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.A./M.Sc./M.Com. DEGREE (REGULAR) EXAMINATION, NOVEMBER 2020

(CBCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2019 Syllabus Year)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each Section/Part.*
2. *The minimum number of questions to be attended from the Section/Part shall remain same.*
3. *There will be an overall ceiling for each Section/Part that is equivalent to maximum weightage of the Section/Part.*

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Give the WK B wave function in a classical region. Explain its features.
2. What is intermediate field Zeeman effect ?
3. Give the general formulation of time independent perturbation theory.
4. Give the criteria for choosing the trial wave function for the first excited excited states for the Variational method.
5. What is electric dipole approximation ?
6. What is scattering amplitude and differential scattering cross section ? How are they related ?
7. Explain hole theory. State the hypotheses which form the basis of the hole theory.
8. What are the draw backs of Klein Gordon equation ?

(8 × 1 = 8 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each question carries weightage 5.

9. Using time independent perturbation theory discuss Weak field and strong field Zeeman effect.

10. Describe the WKB method with respect to connection formulae and apply it to find the wave function inside and outside of a potential well with no vertical walls.

11. Describe briefly the Time dependent perturbation theory and apply it to find the scattering cross section in the Born approximation.

12. Show that the Dirac particles have spin ½.

(2 × 5 = 10 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

13. Apply time independent perturbation theory to find the exact wave function and energy of linear harmonic oscillator.

14. Apply variational method to find the ground state wave function and the ground state energy of Helium atom.

15. Discuss the theory of constant perturbation and deduce Fermi-Golden rule.

16. Deduce the expression for scattering cross section by the method of partial wave expansion for scattering by central potential.

17. For a square well potential show that the scattering cross section is independent of energy and scattering angle.

18. Derive the expression for conserved current from Dirac equation.

19. From the relativistic expression for the Hamiltonian derive the Klein Gordon equation

(4 × 3 = 12 weightage)

D 90744 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION NOVEMBER 2020

(CUCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Give the criteria for validity of WKB approximation.
2. Describe removal of degeneracy on application of magnetic field in the case of hydrogen atom.
3. What is Rayleigh Ritz method ?
4. Give the connection formulae for WKB approximations.
5. How the trial wave function for excited states is chosen for the Variational method ?
6. What is meant by Dyson's series ?
7. Give an account of electric dipole approximation and obtain expression for transition probability for unit time.
8. Give Dirac equation and hence give Dirac Hamiltonian. Give the matrices involved in the equation.
9. What are the draw backs of Klein Gordon equation ?
10. What are the differences between Weyl equations and Dirac equations ?
11. Define conjugate field and Hamiltonian density with respect to fields.
12. What is second quantization ? Give the features of second quantization.

(12 × 1 = 12 weightage)

Turn over

Section B

Answer any **two** *questions.*
Each question carries weightage 6.

13. Discuss the method of Time independent perturbation theory in the case of non-degenerate states and apply the same to find the energy states and wave functions of anharmonic oscillator.

14. Describe briefly the Time dependent perturbation theory and apply it to find the absorption energy from the field in the case of Harmonic perturbation.

15. Discuss spin orbit coupling. Also deduce the Hamiltonian corresponding to the non-relativistic limit of the Dirac equation. Give the interpretations to each term.

16. Derive Euler-Lagrange equation for the fields.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

17. Apply WKB approximation method to find the transmission co-efficient of a potential barrier.

18. Using Variational principle to find the ground state energy for Helium atom.

19. Find the transition probability per unit time for absorption when an atom is placed in electromagnetic field.

20. Derive the quantization rules for bosons.

21. Show that the total angular momentum is a constant of motion for Dirac particles.

22. Derive the Hamiltonian form of the Klein Gordon equation.

(4 × 3 = 12 weightage)

D 70984 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR) EXAMINATION NOVEMBER 2019

Physics

PHY3C09—QUANTUM MECHANICS—II

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions, each carries weightage* 1.

I. Describe how Degeneracy is removed in Stark effect.

2. Describe the principle of WKB approximation

3. How does the height and width of the potential barrier affect the probability of penetration of particles through the barrier ?

4. Describe the principle of Variational method.

5. What is dipole moment operator ? What are the rules that are to be satisfied for the transition probability between two states to be non zero ?

6. What is principle of detailed balance ? Explain why the intensity of stimulated emission between two atomic levels is much less than that of stimulated absorption ?

7. Give the properties of Dirac Matrices.

8. Explain hole theory. State the hypotheses which form the basis of the hole theory .

9. Discuss the features of Klein Gordon equation.

10. Describe the principle of canonical quantization of the field ?

11. Distinguish between function and functional with respect to Lagrangian density.

12. The orbital angular momentum of Dirac particle is not constant of motion. Examine the statement.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions, each carries weightage* 6.

13. Discuss the method of Time independent perturbation theory in the case of degenerate states and apply the same to find the energy states and wave functions to illustrate Zeeman effect in hydrogen atom.

14. Describe briefly the Time dependent perturbation theory and apply it to find the scattering cross section in the first order Born approximation.

Turn over

15. Discuss the plane wave solution of the Dirac equation. Also find the equation of continuity for the Dirac particles.

16. Discuss the quantization of Bosons and Fermions

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions, each carries weightage* 3.

17. Apply WKB approximation method to one dimensional bound system to verify Bohr-Sommerfeld quantization rule of the Old Quantum Theory.

18. Apply Variational principle to find the ground state energy for Helium atom.

19. Apply the first order time dependent perturbation theory to find the absorption energy from the field in the case of Harmonic perturbation.

20. Give the Hamiltonian formulation for the field.

21. Discuss spin orbit coupling of Dirac particle. Derive the expression for the corresponding Hamiltonian.

22. From the relativistic expression for the Hamiltonian derive the Klein Gordon equation.

(4 × 3 = 12 weightage)

D 70979 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE (REGULAR) EXAMINATION
NOVEMBER 2019

Physics

PHY 3C 09—QUANTUM MECHANICS–II

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. What you mean by bound states in quantum mechanics ?
2. What is the importance of Klein Gordan equation over Schrodinger equation ?
3. Write the WKB solution of a radial wave equation.
4. What is spin-orbit coupling in Hydrogen atom and how can we accommodate it in perturbation theory ?
5. What is dipole approximation ?
6. Write the Hamiltonian of a particle in an anharmonic oscillator potential and discuss the methods to solve this quantum mechanically.
7. Write down the Pauli's spin matrices and discuss its eigen values.
8. Discuss the nature of wave-functions of a particle suffering a repulsive potential barrier.
9. What you meant by large and small components in the context of relativistic quantum mechanics ?
10. Write down the Euler - Lagrange equation for fields.
11. Discuss sudden and adiabatic approximation.
12. What is Fermi's Golden rule.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. Discuss Stark effect with perturbation theory .

Turn over

14. Quantize the Klein-Gordon field with necessary theory.

15. Discuss time dependent perturbation theory. What is the transition probability when a system is subjected to a harmonic perturbation ?

16. Using variational principle find the ground state energy of a one dimensional Harmonic oscillator

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

17. Find the energy Eigen values of a particle using WKB method for a one dimensional potential $V(x) = ax^4$.

18. A particle of mass "m" is confined in a one dimensional infinite potential well (from 0 to L). When it is perturbed by a potential $V(x) = V_0$ in the same region (0 to L/2). Find the first order correction in energy.

19. Show that Dirac matrices are anti- commuting.

20. Which of the following transitions is electric Dipole allowed ?

    (a) 1s —> 2s.

    (b) 1s —> 2p.

    (c) 2p —> 3d.

    (d) 3s —> 5d.

21. What are bilinear covariants ?

22. How the vector current does transforms under the operation of charge conjugation ?

(4 × 3 = 12 weightage)

D 52332 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2018

(CUCSS—PG)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2012 Syllabus Year)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. What is the approximation involved in WKB approximation ?
2. Explain the necessity of field quantization.
3. How functional derivatives differed from normal derivatives ?
4. How can we construct Dirac matrices from Pauli's spin matrices ?
5. Write any two bilinear covariants ?
6. What is the basic idea behind variational methods ?
7. Why we treat degenerate perturbation separately in the perturbation theory ?
8. Distinguish Klein Gordon equation from Schrödinger equation.
9. Write the differences between Schrödinger picture and Heisenberg picture.
10. Discuss sudden and adiabatic approximation.
11. What is Fermi's Golden rule ?
12. Write the Gaussian wave-function in one dimension. Explain why it is a suitable choice of trial wave-function in many problems ?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. In the Dipole approximation, discuss the Semi - classical treatment of interaction of an atom with electromagnetic field.
14. How Dirac formulated relativistic equation for equation ? Prove Dirac matrices are trace-less and Eigen values are + 1 or – 1.

Turn over

15. Discuss first order time independent perturbation theory in detail.

16. Using variational principle find the ground state energy of the electron in Hydrogen atom.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries **3** *weightage.*

17. Which of the following transitions is electric Dipole allowed ?

    (a) 1s → 2s.

    (b) 1s → 3d.

    (c) 2p → 5s.

    (d) 3s → 5d.

18. State and prove Noether's theorem for internal symmetry.

19. Check the probability conservation in Klein Gordan field.

20. A particle of mass "m" is confined in a one dimensional infinite potential well (from 0 to L). When it is perturbed by a potential $V(x) = a\,x$ in the same region (0 to L). Find the first order correction in energy. (where "a" is a small constant with appropriate dimension)

21. Find the ground state energy of a One Dimensional Harmonic oscillator using the trial wave-function , $\psi(x) = N\ x\ e^{-bx^2}$ (*N is the normalization constant*).

22. Show that free electrons can neither emit nor absorb photons.

(4 × 3 = 12 weightage)

D 52340 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2018

(CUCSS—PG)

Physics

PHY 3C 09—QUANTUM MECHANICS—II

(2017 Syllabus Year)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions, each question carries weightage* 1.

1. Describe the connection formulae for WKB approximation.
2. Find the energy levels which become non-degenerate under the influence of electric field under first order corrections.
3. Describe the principle of WKB approximation.
4. Describe the principle of Variational mehod.
5. Give the criteria for choosing the trial wave function for excited states for the Variational method.
6. What is electric dipole approximation ?
7. Which of the following transitions is electric dipole allowed ?

   (i) $1s \rightarrow 2s$. (ii) $1s \rightarrow 2p$. (iii) $2p \rightarrow 3d$. (iv) $3s \rightarrow 5d$.
8. Explain large and small components of solutions of Dirac equation.
9. Is spin angular momentum is constant of motion with respect to Dirac Hamiltonian ?
10. What is Weyl equation ? Give its significance.
11. Explain functional derivatives.
12. What is Hamiltonian and Hamiltonian density of the field in the continuum limit ? Explain the symbols.

(12 × 1 = 12 weightage)

Turn over

Section B

Answer any **two** *questions, each question carries weightage* 6.

13. Describe the principle of WKB approximation. Apply the method to find the transmission coefficient through a potential barrier.

14. Discuss the plane wave solutions of Dirac equation.

15. Deduce the expression for transition probability for induced emission for an atom placed in an electromagnetic field.

16. Derive Euler - Lagrange equation for the fields.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions, each question carries weightage* 3.

17. Apply time independent perturbation theory to find the first order correction for energy levels and for wave function of the Anharmonic Oscillator.

18. Use the Variational method to estimate the ground state energy of the hydrogen atom.

19. Apply Time dependent perturbation theory to find the absorption energy from the field in the case of Harmonic perturbation.

20. Derive the Hamiltonian form of Klein Gordon Equation.

21. Find the conserved current due to Dirac equation.

22. Discuss the quantization of fermions.

(4 × 3 = 12 weightage)

C 31289 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2017

(CUCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS-II

(2012 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A (Short Answer type Questions)

Answer **all** *questions.*
Each question carries a weightage of 1.

1. Explain Bohr-Sommerfield quantization theory.
2. Show that the variational method always gives an upper limit to the ground state energy of the system.
3. What is the effect of the application of an electric field in the linear Stark effect ?
4. Write a note on second Quantization.
5. Give the magnitude of the fisrt order perturbation theory.
6. Illustrate the principle of WKB method.
7. What you mean by electric dipole approximation ?
8. Explain Hole theory ?
9. Write KG equation in electromagnetic field.
10. Write the magnetic moment of electron as obtained by Dirac's equation.
11. Explain the Weyl equation.
12. Write weak field interaction Hamiltonian in electromagnetic field.

(12 ×1 =12 weightage)

Section B (Essay type Questions)

Answer any **two** *questions.*
Each question carries a weightage of 6.

13. Outline the variational method used for obtaining the approximation value of the ground state energy of a system. And obtain ground state energy for a hydrogen atom using variational method.
14. Discuss the time independent perturbation theory for a nondegenerate system.

Turn over

15. Discuss the First order time dependant perturbation theory and derive Fermi-Golden Rule 3 ?

16. Derive Dirac's Relativistic wave equation, obtain it from the equation of continuity.

(2 × 6 =12 weightage)

Section C

Answer any **four** *questions.*
Each question carries a weightage of 3.

17. Show that :

    (i) Trace $\gamma_\mu = 0$

    (ii) Det $\gamma_\mu = \pm 1$

18. Estimate the ground state energy of a one dimensional harmonic oscillator of mass m and angular frequency ω using a Gaussian trial function.

19. The unperturbed wave functions of a particle trapped in an infinite square well of bottom are $\Psi_n^0 = \left(\frac{2}{a}\right)^{1/2} \sin\frac{n\pi x}{a}$. If the system is perturbed by raising the floor by a constant amount V_o, evaluate the first and second order corrections to the energy eigen values of n^{th} state.

20. Obtain the selection rule for electric dipole transition of a hydrogen atom.

21. Find transmission coefficient using WKB method.

22. Show that the Dirac's particles have spin ½.

(3 × 4 =12 weightage)

D 71335 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2014

(CUCSS)

PHY 3C 09—QUANTUM MECHANICS

(2012 Admission onwards)

Time : Three Hours Maximum : 36 Weightage

Part A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. Give the magnitude of the first order perturbation energy.
2. What is the effect of the application of an electric field in the linear stark effect ?
3. What are turning points ? Give its significance.
4. What is meant by degeneracy ?
5. Distinguish between stimulated and spontaneous emission.
6. Why does spontaneous emission far exceeds stimulated emission in the visible region ?
7. What are the arguments used in deriving the Klein-Gordon equation ?
8. What do you mean by negative energy states ?
9. Explain what is meant by Pauli Spin matrices.
10. What are indistinguishable particles ? Give example.
11. What is Lamb shift ?
12. Explain Bohr Sommerfield quantum theory.

(12 × 1 = 12 weightage)

Part B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

1. Use the variational method to estimate the energies of a one dimensional harmonic oscillator in the ground state and first excited state.
2. Prove that the WKB approximation gives correct energy Eigen values of all the states of a harmonic oscillator.
3. Outline the Heitler-London theory of the hydrogen molecule and discuss the result.
4. Derive the plane wave solutions of Dirac equation. Write the equation for a Central field.

(2 × 6 = 12 weightage)

Turn over

Part C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

1. A simple harmonic oscillator is perturbed by a harmonic potential so that the result Hamiltonian is given by $H = \frac{p^2}{2m} + \frac{1}{2} m w^2 x^2 + \lambda x^2$. Calculate the first order perturbation energy.
2. Derive the Bohr-Somerfield quantum condition using WKB method.
3. Calculate the Einstein's Coefficients for an electron moving in a central potential.
4. State and explain the postulates of Pauli's theory of Spin. Define Pauli matrices.
5. IF $\bar{\alpha} \times \bar{\beta}$ are Dirac matrices prove that :

   (a) $\alpha_x = \frac{1}{2}[\alpha_x \alpha_y, \alpha_y]$.

   (b) $\alpha_x \alpha_y, \alpha_z = \frac{1}{2}[\alpha_x \alpha_y, \alpha_z \beta, \beta]$.
6. Obtain the spin wave functions for *two* electrons.

(4 × 3 = 12 weightage)

D 91602 (Pages : 2) Name.....

Reg. No.....

THIRD SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2015

(CUCSS)

Physics

PHY 3C 09—QUANTUM MECHANICS

(2012 Admission onwards)

Time : Three Hours Maximum : 36 Weightage

Part A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. A system is subjected to a perturbation which lasts from time $t = 0$ to $t = t_0$ and which is constant during this time. What is the transition probability ?
2. Explain the principle of WKB approximation.
3. Distinguish between Normal and Anomalous Zeeman effects ?
4. Distinguish between Symmetric and antisymmetric functions.
5. What is electric dipole transition moment ? Give its significance.
6. Why is it easier to obtain laser action at the infrared wavelengths compared to visible region ?
7. Give *two* important properties of Dirac matrices.
8. Explain what is meant by Dirac Spin matrices.
9. Explain the concept of change conjugation.
10. Define Symmetric and antisymmetric wave functions.
11. Discuss the principles of variational method.
12. Explain the basic principle of Canonical quantization of fields.

(12 × 1 = 12 weightage)

Part B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

1. Use the variational method to estimate the ground state energy of the Helium atom.
2. Show that a hydrogen atom in its first excited state behaves as though it has permanent electric dipole moment that can be oriented in three different ways.

Turn over

3. Obtain the Hamiltonian operator for a charged particle in an electromagnetic field.
4. Discuss the Hartree's self consistent field method for a many electron system.

(2 × 6 = 12 weightage)

Part C

Answer any **four** *questions.*
Each question carries 3 *weightage.*

1. Use the WKB approximation to calculate the energy levels of a spin less particle of mass m moving in a one dimensional box with walls at $x = 0$ and $x = L$.
2. An unperturbed two level system has energy Eigen values E_1 and E_2 and Eigen functions $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$ When perturbed its Hamiltonian is represented by $\begin{pmatrix} E & A \\ A* & E_2 \end{pmatrix}$. Find the first order and second order correction to E_1.
3. Calculate the rates of stimulated and spontaneous emission for the transition $3P \rightarrow 2S$ (Hα line) of hydrogen atom, taking the atoms are at a temperature of 1000 K.
4. A harmonic oscillator in the ground state is subjected to a perturbation $H^1 = -x \exp.\left(\frac{-t^2}{t_0^2}\right)$ from $t = 0$ to $t = \infty$. Calculate the probability for transition from the ground state, given.
5. Explain the properties of Dirac matrices.
6. N non-interacting bosons are in a infinite potential well defined by $V(x) = 0$ for $0 < x < a$. $V(x) = \infty$ for $x < 0$ and for $x > a$. Find the ground state energy of the system. What would be the ground state energy if the particles are fermions.

(4 × 3 = 12 weightage)