D 130252 **(Pages : 2)** **Name.....**

Reg. No.....

FIFTH SEMESTER (CBCSS—U.G.) DEGREE EXAMINATION
NOVEMBER 2025

Physics/Applied Physics

PHY 5B 07/APH 5B 07—QUANTUM MECHANICS

(2019 Syllabus)

Time : Two Hours Maximum : 60 Marks

Section A (Short Answer Type)

Answer **all** *questions ; each question carries* 2 *marks.*

Ceiling : 20 *marks.*

1. What is Compton wavelength ? Write its value for the electron.
2. Why can a single free electron not absorb a single photon ?
3. Explain the classical theory of the photoelectric effect.
4. Write Bohr's postulate on quantization of angular momentum.
5. Define the Rydberg constant and give its relation with fundamental constants.
6. What is the correspondence principle ?
7. Mention two deficiencies of Bohr's model.
8. What did the Frank-Hertz experiment establish ?
9. State the physical meaning of the wavefunction modulus squared.
10. Write the time-dependent Schrödinger equation for a one-dimensional particle.
11. What is a stationary state ?
12. Write down the general properties of wave functions.

Turn over

Section B (Paragraph/Problem Type)

Answer **all** *questions ;* 5 *marks each.*

Ceiling : 30 *marks.*

13. X-rays of wavelength 0.2400 nm. are Compton-scattered at 60°. (a) Find the scattered wavelength. (b) Find the kinetic energy of the recoil electron.

14. Using Bohr's model, calculate the wavelengths of the Balmer transitions $n = 3 \rightarrow 2$ and $n = 4 \rightarrow 2$ in hydrogen. Take the Rydberg constant $R_H = 1.097 \times 10^7\ m^{-1}$.

15. Calculate the de Broglie wavelength of : (i) a 10 g bullet at 500 ms^{-1} ; (ii) An electron with kinetic energy 1 eV.

16. The uncertainty in the position of an electron in a certain state is $\Delta x = 1.0 \times 10^{-10}$m. Using Heisenberg's principle, estimate the minimum uncertainty in its momentum and the corresponding uncertainty in velocity. (Electron mass $m_e = 9.11 \times 10^{-31}$ kg).

17. A neutron is confined in a nucleus of radius 1.0×10^{-14} m. Model it as a particle in a one-dimensional box of width equal to the nuclear radius. Estimate its ground-state energy.

18. For a one-dimensional infinite well of width L, obtain normalized eigenfunctions and show that the probability of the ground state in [0, L/2] equals $\frac{1}{2}$.

19. In a weak magnetic field, obtain the normal Zeeman splitting pattern for the hydrogen $n = 2$ level and sketch the components.

Section C (Essay Type)

Answer any **one** *question;* 10 *marks each.*

20. Obtain the eigenvalues and eigenfunctions of the simple harmonic oscillator. Plot the energy level diagram.

21. Write down the Schrodinger equation in spherical polar coordinates and, using separation of variables, obtain the functional forms of the radial part R (r), the polar part $\Theta(\theta)$, and the azimuthal part $\Theta(\phi)$.

(1 × 10 = 10 marks)

D 110235 **(Pages : 2)** **Name.....**

Reg. No.....

FIFTH SEMESTER (CBCSS–UG) DEGREE EXAMINATION, NOVEMBER 2024

Physics/Applied Physics

PHY 5B 07/APH 5B 07—QUANTUM MECHANICS

(2019 Admission onwards)

Time : Two Hours Maximum : 60 Marks

Section A - Short Answer type

Answer **all** *questions in two or three sentences.*
Each correct answer carries a maximum of 2 marks.

1. What is meant by probability amplitude ?
2. Discuss uncertainty relationships for classical waves.
3. Define ultraviolet catastrophe.
4. Write down Einstein's photoelectric equation.
5. What do you mean by Bremsstralilung ?
6. State and explain Heisenberg uncertainty relationship.
7. What is meant by a free particle ? Write down the Schrodinger equation for a free particle.
8. Define zero point energy.
9. Explain the significance of Frank hertz experiment.
10. Discuss the fine structure splitting in Hydrogen atom.
11. Write down the Schrodinger equation cf the Hydrogen atom.
12. Discuss The limitations of Bohr atom model.

(Ceiling 20)

Section B – Paragraph / Problem type

Answer **all** *questions in a paragraph of about half a page to one page,*
each correct answer carries a maximum of 5 Marks.

13. X-rays with wavelength 1 A^0 are scattered from a metal block. The scattered radiation is viewed at 90° to the incident radiation. Evaluate the Compton shift.
14. You are using a radiometer to observe the thermal radiation from an object that, is heated to maintain its temperature at 1278K. The radiometer records radiation in a wave length interval of 10.5nm. By changing the wavelength at which you are measuring, you set radiometer to record the most, intense radiation emission from the object. What is the intensity of the emitted, radiation in this interval ?

Turn over

15. Calculate the maximum wave length that hydrogen in its ground state can absorb. What would be the next maximum wavelength.

16. Estimate the minimum velocity that would be measured for a billiard ball (m = 80g) confined to a billiard table of dimension 1m.

17. Prove that i (d/dx) and d^2/dx^2 are Kemntian.

18. Calculate the expectation values of position and momentum of the particles trapped in the one dimensional box of width a.

19. Discuss the four quantum numbers of Hydrogen atom.

(Ceiling 30)

Section C – Essay type

Answer in about two pages, any **one** *question, correct answer carries 10 marks.*

20. Discuss the concept of wave packet. How is it represented analytically ? Also prove that the speed of the particle is equal to the group speed of the corresponding wave packet.

21. What is tunneling ? Write the theory of quantum mechanical tunneling. Write any three applications of tunneling.

(1 × 10 = 10 marks)

D 50691 **(Pages : 2)** **Name.....**

Reg. No.....

FIFTH SEMESTER (CBCSS–UG) DEGREE EXAMINATION, NOVEMBER 2023

Physics/Applied Physics

PHY 5B 07/APH 5B 07—QUANTUM MECHANICS

(2019 Admission onwards)

Time : Two Hours Maximum : 60 Marks

Section A (Short Answer Type)

Answer **all** *questions in two or three sentences, each correct answer carries a maximum of* 2 *marks.*

1. A particle confined in a box must have, a certain minimum energy called zero point energy. Comment.
2. State and explain Bragg's law.
3. Write down Einstein's photoelectric equation.
4. What are stationary states ? Explain the significance of Franck Hertz experiment.
5. Show that the eigenvalues of a Hermition operator are real.
6. State Wien's displacement law.
7. Discuss Rutherford atom model.
8. Explain the postulates of Bohr with regard to hydrogen atom.
9. Prove the nonexistence of electron in the nucleus on the basis of uncertainty principle.
10. What is a wave packet ?
11. What is magnetic quantum number ? Explain its significance.
12. For what state of hydrogen atom, the electrons probability density distribution is spherically symmetric.

(Ceiling 20)

Section B (Paragraph /Problem type)

Answer **all** *questions in a paragraph of about half a page to one page, each correct answer carries a maximum of* 5 *marks.*

13. State and prove correspondence principle.
14. At what wavelength does a room temperature object emit the maximum thermal radiation ? Take T = 27°C. To what temperature must we heat it until its peak thermal radiation is in the red region of the spectrum (680 nm).

Turn over

15. You are using a radiometer to observe the thermal radiation from an object that is heated to maintain its temperature at 1278 K. The radiometer records radiation in a wave length interval of 10.5 nm. By changing the wavelength at which you are measuring, you set radiometer to record the most intense radiation emission from the object. What is the intensity of the emitted radiation in this interval ?

16. Explain Davisson and Germer experiment with proper diagram.

17. An eigen function of the. operator d^2/dx^2 is $\psi = e^{2x}$. Find the corresponding eigen value.

18. For an electron in a one dimensional infinite potential well of width $1A^0$, calculate the separation between the two lowest energy levels and find the frequency and wavelength of the photon corresponding to a transition between these two levels.

19. A sample of a certain element is placed in a 0.300 T magnetic field and suitably excited. How far apart are the Zeeman components of the. 450 nm spectral line of this element ?

(Ceiling 30)

Section C (Essay type)

Answer in about two page., any one question,
the question carries 10 *marks.*

20. Derive the one dimensional time dependent Schrodinger equation.

21. Write the Schrodinger equation for hydrogen atom and obtain the expression for $\Phi, \odot$ and R using separation of Variables.

(1 × 10 = 10 marks)

D 30585 **(Pages : 2)** **Name.....**

Reg. No.....

FIFTH SEMESTER (CBCSS—UG) DEGREE EXAMINATION
NOVEMBER 2022

Physics/Applied Physics

PHY 5B 07/APH 5B 07—QUANTUM MECHANICS

(2019 Admission onwards)

Time : Two Hours Maximum : 60 Marks

The symbols used in question paper have their usual meanings.

Section A (Short Answer Type)

Answer **all** *questions in two* or *three sentences.*
Each correct answer carries a maximum of 2 *marks.*

1. Plot the radiancy versus wavelength spectrum of a blackbody for two different temperatures.
2. What is the origin of the unmodified peak in the Compton spectrum ?
3. List any four basic properties of photons.
4. Explain Ritz combination principle.
5. What was the purpose of Davisson-Germer experiment ?
6. Explain the principle of complementarity.
7. Explain how the amplitude of de Broglie wave related to the probability of finding the particle.
8. Discuss the probability interpretation of wavefunction.
9. Give an expression for the energy eigen values of a one-dimensional simple harmonic oscillator. How is it different from that of a particle in a box, in terms of the spacing ?
10. Discuss the ammonia inversion problem using quantum mechanical tunneling.
11. Explain the result of Stern-Gerlach experiment using a suitable example.
12. What is Bohr magneton ? What is its value ?

(Ceiling 20)

Turn over

Section B (Paragraph/Problem Type)

Answer **all** *questions in* **a paragraph of about half a page to one page**.
Each correct answer carries a maximum of 5 *marks.*

13. X-rays of wavelength 0.24 mm are Compton-scattered and the scattered beam is observed at an angle 60 degree relative to the incident beam. Determine :

    (a) The wavelength of the scattered X-rays ; and

    (b) Energy of the scattered X-rays.

14. Discuss the basic properties of atoms.

15. Calculate the de Broglie wavelength of an electron having a kinetic energy 1 eV.

16. An electron moves in the x direction with a speed of 3.6×10^6 m/s. We can measure its speed to a precision of 1 %. With what precision can we simultaneously measure its position ?

17. Determine the average value of the position of a particle trapped in a one dimensional box of length L.

18. What are the quantum numbers associated with an atomic electron and what are their possible values ?

19. Explain normal and anomalous Zeeman effects.

(Ceiling 30)

Section C (Essay Type)

Essays.
Answer in about **two pages,** *any* **one** *question, correct answer carries* 10 *marks.*

20. Discuss the Rutherford nuclear atom model.

21. Setup the time-independent Schrödinger equation in one dimension.

(1 × 10 = 10 marks)

D 10682 **(Pages : 2)** **Name.....**

Reg. No.....

FIFTH SEMESTER U.G. DEGREE EXAMINATION, NOVEMBER 2021

(CBCSS—UG)

Physics/Applied Physics

PHY 5B 07/APH 5B 07—QUANTUM MECHANICS

(2019 Admissions)

Time : Two Hours Maximum : 60 Marks

The symbols used in question paper have their usual meanings.

Section A (Short Answer Type)

Answer at least **eight** *questions.*
Each question carries 3 *marks.*
All questions can be attended.
Overall Ceiling 24.

1. Give an expression for the Poynting vector. What is its dimension ?
2. Write down the Compton scattering formula. Explain the terms involved.
3. Draw the schematic of the Franck-Hertz experiment indicating the parts involved.
4. Write down the Balmer formula and explain the terms involved.
5. Discuss the Bohr's correspondence principle.
6. Write down the energy-time uncertainty principle and explain the terms involved.
7. Write and explain the normalization condition of a wavefunction.
8. Explain the term degeneracy of eigen states.
9. Write down the Schrödinger equation for a free particle and give its solution.
10. Write down the form of hydrogen atom wavefunction, indicating the variables and the quantum numbers involved.
11. Explain the purpose of Stern-Gerlach experiment.
12. What is normal Zeeman effect ?

(8 × 3 = 24 marks)

Turn over

Section B (Paragraph/Problem Type)

Answer at least **five** *questions.*
Each question carries 5 *marks.*
All questions can be attended.
Overall Ceiling 25.

13. List the experimental results of photoelectric effect.
14. Discuss the assumptions of Thomson's model. Explain the failures of this model.
15. Calculate the two longest wavelengths of the Balmer series of triply ionized beryllium (Z = 4).
16. Calculate the de Broglie wavelength of an electron having a kinetic energy 1000 eV.
17. Explain the problem of quantum mechanical tunneling. Discuss an example.
18. Plot the lowest three energy levels and the corresponding probability densities of a one dimensional simple harmonic oscillator with finite potential.
19. What are the possible z components of the angular momentum vector L which represents the orbital angular momentum of a state with orbital angular momentum quantum number $l = 2$. What is the length of the angular momentum vector ?

(5 × 5 = 25 marks)

Section C (Essay Type)

Answer any **one** *question.*
The question carries 11 *marks.*

20. Discuss the Davisson-Germer experiment and the results obtained.
21. Obtain the eigenfunctions and energy eigenvalues of a particle confined to a onedimensional box.

(1 × 11 = 11 marks)