

D 50209

(Pages : 3)

Name.....

Reg. No.....

**FIFTH SEMESTER (CUCBCSS—UG) DEGREE EXAMINATION
NOVEMBER 2023**

Physics/Applied Physics

PHY 5B 07/APY 5B 08—QUANTUM MECHANICS

(2018 Admissions)

Time : Three Hours

Maximum : 80 Marks

Section A*Answer all questions.**Each correct answer carries a maximum of 1 mark.*

1. Emissivity of a black body is _____.
2. For pair production phenomenon to occur the photon must have energy, greater than or equal to _____.
3. Probability density is represented by _____.
4. The experiment that confirms the existence of de Broglie wave is _____.
5. An electron can circle in a nucleus only if its orbit contains an _____ of de Broglie wavelengths.
6. The nuclear mass affects the _____ of spectral lines.
7. Commutation bracket is _____.
8. Write down the one dimensional time dependent form of Schrodinger equation.
9. The splitting of spectral lines by a magnetic field is called _____.
10. The space quantization of electron spin is described by _____ quantum number.

(10 × 1 = 10 marks)

Turn over

Section B (Short Answer Type)

Answer all questions.

Each correct answer carries a maximum of 2 marks.

11. What do you mean by gravitational red shift ?
12. What does the Heisenberg uncertainty principle imply ?
13. Write down three dimensional form of time dependent Schrodinger equation.
14. Define expectation value.
15. Define zero point energy.
16. Define spin of an electron.
17. Write down the Schrodinger equation of the Hydrogen atom.

(7 × 2 = 14 marks)

Section C

Answer any five questions in a paragraph of about half a page to one page,

Each correct answer carries a maximum of 4 marks.

18. Write a note on pair production.
19. Write a note on electron microscope.
20. Briefly discuss Particle in a one dimensional box problem.
21. What do you mean by tunneling ? Write the principle of scanning tunneling microscope.
22. Distinguish between eigen value and eigen function.
23. Write a note on Zeeman effect.
24. Write a note on Line spectra of Hydrogen atom.

(5 × 4 = 20 marks)

Section D (Problems)

Answer any four questions.

Each correct answer carries a maximum of 4 marks.

25. X rays of wavelength 0.7080 \AA are scattered from a carbon block through an angle of 90° . Evaluate the Compton shift.
26. Obtain the relation between group velocity and phase velocity.

27. An electron collides with a hydrogen atom in its ground state and excites into a state of $n = 3$. How much energy was given to the hydrogen atom in this inelastic collision ?
28. Find the probability that a particle trapped in a box L wide can be found between $0.45L$ and $0.55L$ for the ground and first excited states.
29. An eigen function of the operator d^2/dx^2 is $\psi = e^{2x}$. Find the corresponding eigen value.
30. Find the equatorial velocity of an electron under the assumption that it is a uniform sphere of radius $r = 5 \times 10^{-17}$ m that is rotating about an axis through its center.
31. Discuss the four quantum numbers of Hydrogen atom.

(4 × 4 = 16 marks)

Section E

Answer in about two page, any two question.

Each correct answer carries 10 marks.

32. Give an account of Einstein's explanation of photoelectric effect on the basis of quantum theory.
33. What is a wave packet ? How is it represented mathematically and diagrammatically ? Define phase velocity and group velocity
34. Write an essay on Franck Hertz Experiment.
35. Obtain the eigen function and eigen value of a quantum harmonic oscillator.

(2 × 10 = 20 marks)

D 30196

(Pages : 3)

Name.....

Reg. No.....

**FIFTH SEMESTER (CUCBCSS—UG) DEGREE EXAMINATION
NOVEMBER 2022**

Physics /Applied Physics

PHY 5B 07/APY 5B 08—QUANTUM MECHANICS

(2017—2018 Admissions)

Time : Three Hours

Maximum : 80 Marks

Section A*Answer all questions in a word or phrase.**Each question carries 1 mark.*

1. Phenomenon in which a photon in the visible region of the spectrum is shifted towards the red end is called.
2. Expression for de Broglie wavelength is.
3. Write down the name of the experiment that confirms the existence of atomic energy level.
4. Write down the normalization condition of any system.
5. Write any one example of Hermitian operator.

Write True or False :

6. In pair production electromagnetic energy is converted into matter.
7. A group of wave need have the same velocity as the waves themselves.
8. If two operators does not commute, then the observable corresponding to them are simultaneously measurable.
9. For a harmonic oscillator the lowest energy will be $E = E_0$.
10. The quantization of angular momentum direction in the hydrogen atom is described by the orbital quantum number.

(10 × 1 = 10 marks)

Section B (Short Answer Type)*Answer all questions in two or three sentences.**Each question carries 2 marks.*

11. Differentiate between group velocity and phase velocity.
12. State correspondence principle.

Turn over

13. What do you mean by zero point energy.
14. State any two postulates in quantum mechanics.
15. What are operators ?
16. Write down the selection rules in hydrogen atom.
17. Write down the Schrodinger equation for hydrogen atom.

(7 × 2 = 14 marks)

Section C (Paragraph Type)

Answer any **five** questions in a paragraph of about **half a page** to one page.

Each question carries 4 marks.

18. How classical physics failed to account for the spectral distribution of energy density in a black body ?
19. State and explain uncertainty principle.
20. Write a note on Frank - Hertz experiment.
21. Write the Schrodinger equation and find the form of the wave functions of a square well potential with rigid walls.
22. Discuss tunnel effect.
23. What are the quantum numbers used in hydrogen atom ? Explain.
24. Discuss stern Gerlack experiment.

(5 × 4 = 20 marks)

Section D (Problems)

Answer any **four** questions.

Each question Carries 4 marks

25. X-rays with $\lambda = 1.0 \text{ \AA}$ are scattered from a metal block. The scattered radiations are viewed at 90° to the incident direction. Evaluate the Compton shift.
26. Prove that the group velocity of the wave packet V_g is the same as the velocity of the material particle.
27. A Positronium atom is a system that consists of a positron and an electron that orbit each other. Compare the wavelengths of the spectral lines of positronium with those of ordinary hydrogen.

28. Find the energy required to excite an electron in hydrogen atom to its first excited state.
29. Prove that operators having common set of eigen functions commute each other.
30. An eigen function of the operator d^2/dx^2 is $\psi = e^{2x}$. Find the corresponding eigen value.
31. Find the average value of l/r for a l 's electron in the hydrogen atom.

(4 × 4 = 16 marks)

Section E (Essays)

Answer any **two** questions in about **two** pages.

Each question carries 10 marks.

32. Give an account of Einstein's explanation of photoelectric effect on the basis of quantum theory.
33. With neat diagram explain Davisson - Germer experiment for the confirmation of de Broglie wave.
34. Derive the one dimensional time dependent Schrodinger equation.
35. Discuss Zeeman effect. With neat diagram show that the normal Zeeman effect consists of splitting of a spectral line in to three components.

(2 × 10 = 20 marks)

D 10244

(Pages : 3)

Name.....

Reg. No.....

FIFTH SEMESTER U.G. DEGREE EXAMINATION, NOVEMBER 2021

(CUCBCSS—UG)

Physics/Applied Physics

PHY 5B 07/APY 5B 08—QUANTUM MECHANICS

Time : Three Hours

Maximum : 80 Marks

Section A*Answer all questions in a word or phrase.**Each question carries 1 mark.*

1. Einstein's photoelectric equation is _____.
2. Write down the energy eigen value of particle in a one dimensional box.
3. Write down the uncertainty relation between energy and time.
4. Write down the selection rules for allowed transitions in a hydrogen atom.
5. Write down the one dimensional time dependent Schrodinger equation.
Write true or false :
6. Although they lack rest mass, photons behave as though they have gravitational mass.
7. A group of waves need have the same velocity as the waves themselves.
8. An electron can circle a nucleus only if its orbit contains an integral number of de Broglie wavelengths.
9. For a harmonic oscillator the lowest energy will be $E = 0$.
10. The quantization of electron energy in the hydrogen atom is described by the principal quantum number.

(10 × 1 = 10 marks)

Section B (Short Answer Type)*Answer all questions in two or three sentences.**Each question carries 2 marks.*

11. Define group velocity.
12. State the postulates of Bohr atom model.
13. Write down the eigen value equation and define eigen value and eigen function.

Turn over

14. What are Hermitian operators ? Write one example.
15. Write down the validity conditions of wave functions.
16. State Exclusion principle.
17. Bring out the conclusion of Stern Gerlach experiment.

(7 × 2 = 14 marks)

Section C (Paragraph Type)

Answer any **five** questions in a paragraph of about **half a page to one page**.

Each question carries 4 marks.

18. Write a short note on Compton effect.
19. Discuss the principle and working of electron microscope.
20. Discuss Correspondence principle.
21. Write a short note on tunnel effect.
22. Write a note on scanning tunneling microscope.
23. Briefly discuss Zeeman effect.
24. What are the quantum numbers used in hydrogen atom ? Explain.

(5 × 4 = 20 marks)

Section D (Problems)

Answer any **four** questions.

Each question carries 4 marks.

25. The threshold frequency of a certain metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incident on the metal, then find the cut off voltage for photo electric emission.
26. An electron has a speed of 500m/s with an accuracy of 0.004%. Calculate the certainty with which we can locate the position of the electron.
27. A Positronium atom is a system that consists of a positron and an electron that orbit each other. Compare the wavelengths of the spectral lines of positronium with those of ordinary hydrogen.
28. Find the shortest and longest wavelength in the Balmer series.
29. Prove that commuting operators have common set of eigen functions.

30. A particle limited to the x -axis has the wave function $\psi = ax$ between $x = 0$ and $x = 1$; $\psi = 0$ elsewhere : (a) find the probability that the particle can be found between $x = 0.45$ and $x = 0.55$; (b) find the expectation value of the position of the particle.
31. A sample of a certain element is placed in a 0.300T magnetic field and suitably excited. How far apart are the Zeeman components of the 450nm spectral line of this element ?

(4 × 4 = 16 marks)

Section E (Essays)

Answer any **two** questions in about **two** pages.

Each question carries 10 marks.

32. Explain ultraviolet catastrophe. With reference to Planck's formula explain how Max Planck solve this discrepancy.
33. What do you mean by de Broglie waves ? Explain the experiment that confirms the existence of de Broglie waves.
34. Explain the different postulates of quantum mechanics in detail.
35. Write the Schrodinger equation for hydrogen atom and obtain the expression for Φ , Θ and R using separation of Variables.

(2 × 10 = 20 marks)

D 90244

(Pages : 4)

Name.....

Reg. No.....

**FIFTH SEMESTER B.A./B.Sc. DEGREE EXAMINATION
NOVEMBER 2020**

(CUCBCSS—UG)

Physics/Applied Physics

PHY 5B 07/APY 5B 08—QUANTUM MECHANICS

Time : Three Hours

Maximum : 80 Marks

Section A (One Word)

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

1. Einstein's photoelectric equation is based on the law of conservation of _____.
2. The expectation value of energy is _____.
3. The de Broglie wavelength of an electron having a kinetic energy of 10 eV is _____.
4. The group velocity for a relativistic particle having a momentum 'p' and energy 'E' is _____.
5. The wave length of a particle in a finite potential well is _____ smaller than that of the particle in a box.

Write True or False :

6. The quantum mechanical operator for energy is $-i\hbar \frac{\partial}{\partial x}$.
7. Compton effect is associated with X-rays.
8. The wave velocity of a wave packet is called group velocity.
9. Davissons and Germer experiment relates electron diffraction.
10. The value of $[L_x, L_y]$ is $i\hbar$.

(10 × 1 = 10 marks)

Turn over

Section B

Answer at least six questions.

Each question carries 2 marks.

All questions can be attended.

Overall Ceiling 12.

11. Distinguish between Wave and Group velocity.
12. What is photoelectric effect ?
13. Explain the term eigen function.
14. Why do we say that Compton effect cannot be explained by classical physics ?
15. What do you mean by expectation values ?
16. What is the basic working principle of an electron microscope ?
17. What is the significance of eigen values ?

(6 × 2 = 12 marks)

Section C

Answer at least four questions.

Each question carries 5 marks.

All questions can be attended.

Overall Ceiling 20.

18. Bring out the angular momentum operators and their basic commutation relations ?
19. Discuss briefly the wave nature of matter and obtain an expression for de Broglie wavelength for matter waves.
20. Explain the normal Zeeman effect.
21. A hydrogen atom is 5.3×10^{-11} m. in radius. Use the uncertainty principle to estimate the minimum electron can have in this atom.
22. Show that $[L_x, L^2] = 0$ and $[L_x, L_y] = i\hbar L_z$.
23. Write a note on the physical interpretation of probability current density.
24. Explain pair production phenomenon. Is it possible for pair production in free space.

(4 × 5 = 20 marks)

Section D

Answer at least three questions.

Each question carries 6 marks.

All questions can be attended.

Overall Ceiling 18.

25. What is the ratio of the kinetic energy of an electron to that of a proton if their de Broglie wavelengths are equal ?
26. A hydrogen atom in a state having binding energy of 0.85 eV makes a transition to a state with an excitation energy of 10.2 eV. Calculate the energy of the emitted photon.
27. X-rays with $\lambda = 1.0 \text{ \AA}$ are scattered from a metal block. The scattered radiation is viewed at 90° to the incident direction. Evaluate the Compton shift.
28. Calculate the de Broglie wavelength of an electron having kinetic energy of 5000 eV.
29. An electron has a speed of 500 m/s with an accuracy of 0.004 %. Calculate the certainty which we can locate the position of the electron.
30. Find the energy of an X-ray photon which can impart a maximum energy of 100 keV to an electron.
31. What is the potential difference that must be applied to stop the fastest photoelectrons emitted by a surface when electromagnetic radiation of frequency $1.5 \times 10^{15} \text{ Hz}$ is allowed to fall on it ? The work function of the surface is 5 eV.

(3 × 6 = 18 marks)

Section E

Answer any two questions.

Each question carries 10 marks.

32. What is photoelectric effect ? Give the quantum mechanical explanation of photoelectric effect and hence obtain Einstein's equation for it.
33. Explain tunnel effect observed in case of a particle approaching a potential barrier of finite width with kinetic energy less than the barrier height.

Turn over

34. What are the postulates of quantum mechanics ? Derive Schrödinger equation. What is the significance of wave function ?
35. What are the essential features of Bohr atom model ? Discuss the origin of the spectral series of hydrogen.

(2 × 10 = 20 marks)

FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2019

(CUCBCSS-UG)

Physics/Applied Physics

PHY 5B 07/APY 5B 08—QUANTUM MECHANICS

Time : Three Hours

Maximum : 80 Marks

Section A

*Answer all questions in a word or phrase.**Each question carries 1 mark.*

1. The wave velocity of a wave packet is called _____.
2. The eigen value of the momentum of the particle in a box is _____.
3. Compton effect is associated with _____.
4. The quantum mechanical operator for energy is _____.
5. The de Broglie wave length of an electron having a kinetic energy of 10 eV is _____.

Write True or False :

6. The value of $[x, p_x]$ is $i\hbar$.
7. The eigen value of the momentum of the particle in a box is discrete.
8. The wavelength of a particle in a finite potential well is smaller than that of the particle in a box.
9. Davissons and Germer experiment establishes the wave nature of matter.
10. The duration of radar pulse is 10^{-6} s, the uncertainty in energy would be zero.

(10 × 1 = 10 marks)

Section B (Short Answer Type)

*Answer all questions in two or three sentences.**Each question carries 2 marks.*

11. State uncertainty principle.
12. What is the physical significance of a wave function ?
13. What is zero point energy ?
14. Briefly explain Pauli's exclusion principle.
15. What is group velocity ? Give example.
16. What are operators ?
17. Give the expression for de Broglie wavelength.

(7 × 2 = 14 marks)

Section C (Paragraph Type)

*Answer any five questions in a paragraph of about half a page to one page.**Each question carries 4 marks.*

18. Deduce Einstein's photoelectric equations.
19. Obtain time-dependent form of Schrödinger's equation.

Turn over

20. Explain Bohr radius of a hydrogen atom. Give the expression for radius of orbits in terms of the Bohr radius.
21. Normalize the wave function $\psi(x) = e^{-x/a}$.
22. Find the expectation value $\langle x \rangle$ of the position of a particle trapped in a box.
23. Give a brief account on gravitational red shift. Obtain the expression for the relative frequency change.
24. Explain Frank-Hertz experiment with examples.

(5 × 4 = 20 marks)

Section D (Problems)

*Answer any four questions.
Each question carries 4 marks.*

25. When radiation of wavelength 1500 Å is incident on a photocell, electrons are emitted? If the stopping potential is 4.4 volts. Calculate the threshold frequency, work function and threshold wavelength.
26. If the position of a 5 keV electron is located with 2Å. What is the percentage uncertainty in its momentum?
27. If a photon has wavelength equal to Compton wavelength of the particle, show that the photon's energy is equal to the rest energy of the particle.
28. Calculate the de Broglie wavelength of an electron having kinetic energy of 1000 eV.
29. Find the energy of an X-ray photon which can impart a maximum energy of 50 keV to an electron.
30. Find the phase and group velocities of the de Broglie waves of an electron whose speed is 0.9 C.
31. Calculate the maximum wavelength that hydrogen in its ground state can absorb. What would be the next maximum wavelength?

(4 × 4 = 16 marks)

Section E (Essays)

*Answer any two questions in about two pages.
Each question carries 10 marks.*

32. What is meant by Compton effect? Derive an expression for the Compton shift.
33. What is photoelectric effect? Describe the laws of photoelectric effect. Give the quantum mechanical explanation of photoelectric effect and hence obtain the Einstein's equation for it.
34. Give an brief account on the quantum numbers associated with hydrogen atom. Give their values. Explain the significance of the quantum numbers.
35. Discuss the uncertainty principle and its relevance in quantum mechanics.

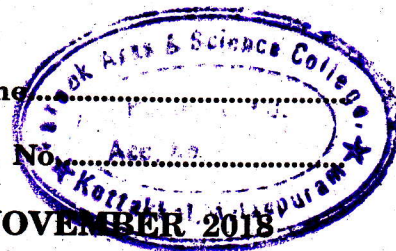
(2 × 10 = 20 marks)

D 50607

(Pages : 2)

Name

Reg. No.



FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2018

(CUCBCSS—UG)

Physics/Applied Physics

PHY 5B 07/APY 5B 08—QUANTUM MECHANICS

Time : Three Hours

Maximum : 80 Marks

Section A

Answer all questions.

1. Write down Rayleigh-Jeans formula.
2. Average energy of Planck's oscillator is _____.
3. Write down uncertainty principle.
4. Write down energy time uncertainty relation.
5. Write the expression for Balmer series.
6. The spectral series of Hydrogen in ultra violet regions.
7. Write down the expression for orbital radius of Hydrogen atom in terms of Bohr radius.
8. Write down the condition for normalization of the wave function.
9. Orbital angular momentum quantum number can have the values _____.
10. Operator correspondence of energy is _____.

(10 × 1 = 10 marks)

Section B

Answer all questions.

11. What is photoelectric effect.
12. Explain pair production.
13. Explain Schwarzschild radius.
14. Distinguish between phase and group velocity.
15. Write down the Bohr Postulates.
16. Write down the admissibility condition for a function to become wave function.
17. Distinguish between 'classical state' with 'Quantum state'.

(7 × 2 = 14 marks)

Turn over

Section C

Answer any five questions.

18. Derive the expression for gravitational red shift.
19. Explain the working of electron microscope using a diagram.
20. Explain Frank-Hertz experiment
21. Derive the steady state Schrodinger equation from time dependent Schrodinger equation.
22. Write a short note on scanning tunneling microscope.
23. Give the idea of allowed transition and forbidden transition.
24. Explain Zeeman effect.

(5 × 4 = 20 marks)

Section D

Answer any four questions.

25. What potential difference must be applied to stop fastest photoelectrons emitted by a surface when electromagnetic radiation of frequency 1.5×10^{15} Hz is allowed to fall on it. The work function of the surface is 5 eV.
26. X-rays of wave length 80 pm are scattered 120° by a largest. Find out the scattered wave length.
27. Calculate the de-Broglie wave length of an electron having kinetic energy of 1000 eV. Compare the result with the wave lengths of X-rays having same energy.
28. The average life time of an excited atomic state is 10^{-9} s. If the spectral line associated with the decay of this state is 6000 \AA , estimate the width of the line.
29. Calculate the maximum wave length that Hydrogen in its ground state can absorb.
30. Find the expectation value $\langle x \rangle$ of the position of a particle trapped in a box L wide.
31. Find out the normalization constant 'A' of the azimuthal wave function for Hydrogen atom, with $\Phi = Ae^{im\phi}$.

(4 × 4 = 16 marks)

Section E

Answer any two questions.

32. What is Compton effect ? Derive the expression for shift in the wave length ? Write the salient features of Compton effect.
33. Derive the energy eigen values and eigen function of particle confined in a box.
34. Obtain the Schrodinger equation for Hydrogen atom in spherical polar co-ordinates and obtain the differential equation for r, θ , ϕ by using separation of variable method.
35. What are matter waves ? Derive the expression for wavelength of matter waves. Describe Davisson- Germer experiment to establish the wave nature of particle.

(2 × 10 = 20 marks)

C 30313

(Pages : 3)

Name.....

Reg. No.....

FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2017

(CUCBCSS—UG)

Physics/Applied Physics

PHY 5B 07/APY 5B 08—QUANTUM MECHANICS

Time : Three Hours

Maximum : 80 Marks

Section A

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

1. Give Planck's distribution law.
2. Density of states of Planck's oscillator in black body between frequencies ν and $\nu + d\nu$.
3. Write down de-Broglie's equation.
4. Write the formula of Compton effect.
5. Write expression for Lyman series.
6. The spectral series of Hydrogen in visible region.
7. Expression for energy of Hydrogen atom in terms of ground state energy.
8. Write the expression for probability density of a system.
9. Write down the possible values of magnetic quantum number.
10. Operator correspondence of lineal momentum is _____.

(1 × 10 = 10 marks)

Section B

*Answer all questions.
Each question carries 2 marks.*

11. Explain Ultra-Violet catastrophe ?
12. Write the salient features of Compton effect.
13. Explain pair annihilation.
14. Distinguish between gravitational red shift and Doppler red shift.
15. Explain Bohr correspondence principle.
16. Explain expectation value of an observable.
17. Write and explain Pauli's exclusion Principle.

(7 × 2 = 14 marks)

Turn over

Section C

Answer any five questions.

Each question carries 4 marks.

18. Show that pair production cannot occur in empty space.
19. Show that group velocity is particle velocity
20. Write a short note on Davisson-Germers experiment.
21. Write down the Postulates of Quantum Mechanics.
22. Explain quantum tunneling and write approximate value of transmission probability.
23. Explain Stern-Gerlach experiment.
24. Explain anomalous- Zeeman effect.

(5 × 4 = 20 marks)

Section D

Answer any four questions.

Each question carries 4 marks.

25. The work function of barium and tungsten are 2.5 eV and 4.2 eV, respectively. Check whether these materials are useful in a photocell, which is to be used to detect visible light.
26. A photon of energy 1.02 MeV. Undergoes a Compton Scatterings through 180°. Calculate the energy of scattered photon.
27. Determine the de-Broglie wave length of an electron that has been accelerated through a potential difference of 100 V.
28. An electron has a speed of 500 m/s with an accuracy of 0.004 %. Calculate the certainty with which we can locate the position of the electron.
29. Determine the ionization energy of He⁺ ion. Also calculate the minimum frequency a photon must have to cause ionization.
30. The operator $\left[X + \frac{d}{dx} \right]$ has the eigen value a. Find the corresponding eigen function.
31. Normalize the normal wave function $\Phi = Ae^{-ax}$ for $x > 0$ and $\Phi = Ae^{ax}$ for $x < 0$, where a is a positive constant.

(4 × 4 = 16 marks)

Section E

Answer any two questions.

Each question carries 10 marks.

32. Derive the time independent Schrödinger's equation from time dependent Schrödinger equation. Apply it to find the energy eigen value of particle confined in a box.
33. Solve the problem of quantum harmonic oscillator by using Schrödinger equation.
34. Explain Bohr Postulates of the atomic structure. Derive the expression for Bohr orbit and total energy of the hydrogen atom.
35. What is Photoelectric effect ? Describe important features of photoelectric effect and derive the Einstein-photo electric equation.

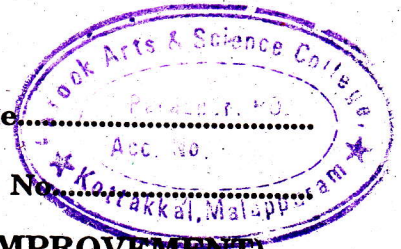
(2 × 10 = 20 marks)

D 11553

(Pages : 4)

Name.....

Reg. No.....



**FIFTH SEMESTER B.Sc. DEGREE (SUPPLEMENTARY/IMPROVEMENT)
EXAMINATION, NOVEMBER 2016**

(UG—CCSS)

Physics/Applied Physics

PH 5B 10/AP 5B 12—QUANTUM MECHANICS

(2009—2012 Admissions)

Time : Three Hours

Maximum : 30 Weightage

Section A

Answer all questions.

Each question carries $\frac{1}{4}$ weightage.

1. The problem of ultraviolet catastrophe was predicted by :
 - (a) Stefan Boltzmann law.
 - (b) Planck's law.
 - (c) Wien's law.
 - (d) Rayleigh Jeans law.
2. When the intensity of light incident on a metal surface is increased, the photoelectric current :
 - (a) Decreases.
 - (b) Increases.
 - (c) Remains.
 - (d) Becomes zero.
3. In Compton scattering the incident photon loses maximum energy to the electron when the photon is scattered at :
 - (a) 0 degree.
 - (b) 180 degrees.
 - (c) 90 degrees.
 - (d) 45 degrees.
4. If a proton and an electron have the same de Broglie wavelength then :
 - (a) Both have same kinetic energies.
 - (b) Proton has more KE than electron.
 - (c) Electron has more KE than proton.
 - (d) Both have same velocity.
5. The particle and wave aspects of a physical entity are :
 - (a) Perturbations.
 - (b) Complementary.
 - (c) Non complimentary.
 - (d) None of these.

Turn over

6. Davisson Germer experiments confirm the existence of :
- (a) Matter waves.
 - (b) Electromagnetic waves.
 - (c) Gravitational waves.
 - (d) Black body radiation.
7. Stern Gerlach experiment gives a direct confirmation of :
- (a) Space quantization.
 - (b) Spin of electron.
 - (c) Wave nature of electron.
 - (d) Quantized atomic magnetic moment.
8. The ground state energy of a hydrogen electron is :
- (a) 13.6 Joules.
 - (b) 13.6ev.
 - (c) - 13.6ev.
 - (d) - 3.4ev.
9. According to Schrödinger a particle is equivalent to a :
- (a) Single wave.
 - (b) Wave pocket.
 - (c) Light wave.
 - (d) None of these.
10. Of the following moving with the same velocity which has the largest wavelength ?
- (a) Photon.
 - (b) Neutron.
 - (c) α particle.
 - (d) Electron.
11. According to wave machine a free particle can possess :
- (a) Discrete energies.
 - (b) Only one single value of energy.
 - (c) Continuous energies.
 - (d) All these.
12. Which *one* of the following pairs of phenomena illustrates the particle aspect of wave particle duality ?
- (a) Compton effect and Bragg's law.
 - (b) Photo electric effect and Compton effect.
 - (c) Compton effect and Pauli's exclusion principle.
 - (d) Photo electric effect and Bragg's law.

(12 \times $\frac{1}{4}$ = 3 weightage)

Section B

Answer all questions.

Each question carries 1 weightage.

- 13 Under what conditions does the average energy of a quantum oscillator & classical oscillator coincide. Reason your answer.
- 14 Low frequency light cannot trigger photoelectric effect. Why ?
- 15 What are the conservation laws satisfied in a Compton scattering experiment ?
- 16 Distinguish between Phase velocity and group velocity.
- 17 What intrinsic property of electron is reflected in the fine structure splitting of spectral lines of hydrogen like atoms ?
- 18 Show that eigen values of a Hermitian operator are real.
- 19 Explain zero point energy.
- 20 Distinguish between allowed transitions and forbidden transitions.
- 21 Why is it that a particle in a three dimensional box requires three quantum numbers for its description ?

(9 × 1 = 9 weightage)

Section C

Answer any five questions.

Each question carries 2 weightage.

- 22 Find the average energy in eV of a Planck's oscillator of frequency 1.9×10^{14} Hz at 1527°C (Assume $e^5 \sim 148$).
- 23 Describe Millikan's experiment for the verification of Einstein's photoelectric equation.
- 24 Light of wavelength 4500\AA ejects photo electrons from a sodium surface of work function 2.3eV. The stopping potential is experimentally found to be 0.46 volts. Calculate Planck's constant.
- 25 A free electron at rest is struck by a photon of wavelength 0.5 nm. Calculate its speed after collision if the photon is scattered backwards. (Assume electron motion is non relativistic)
- 26 Calculate the de Broglie wavelength of a 1 keV electron and 1keV proton.
- 27 Explain spin orbit interaction example.
- 28 Explain Zeeman splitting of the sodium D lines in a weak magnetic field.

(5 × 2 = 10 weightage)

Section D

Answer any two questions.

Each question carries 4 weightage.

- 29 What is Compton effect ? Derive an expression for the frequency shift of protons as a function of the angle of scattering for Compton effect using energy momentum conservation.
- 30 Explain Bohr's postulates of the atomic structure. Derive expressions for the radius of the Bohr orbit and total energy of the hydrogen atom.
- 31 Derive the Schrödinger's equation for a linear harmonic oscillator and solve it to obtain the eigen values and eigen functions.
- 32 What is space quantization ? Describe Stern Gerlach's experiment. How does it prove the existence of magnetic moment and electron spin ?

(2 × 4 = 8 weightage)

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(Pages : 3)

Name.....

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FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2016

(CUCBCSS-UG)

Physics/Applied Physics

PHY 5B 07/APY 5B 08—QUANTUM MECHANICS

Time : Three Hours

Maximum : 80 Marks

The symbols used in this question paper have their usual meanings.

Section A

Answer all questions in a word or a phrase.

Each question carries 1 mark.

1. In photoelectric effect, for a particular frequency, the number of photoelectrons emitted is proportional to _____ of the radiation.
2. What is the relation between particle momentum and the wave number of the de Broglie wave associated with it ?
3. Which spectral series of hydrogen falls in the visible region of the electromagnetic spectrum ?
4. What are the eigen functions of a quantum harmonic oscillator ?
5. What is the magnitude of angular momentum due to spin of an electron ?

Write True or False :

6. Davissons and Genner experiment confirms wave nature of electrons.
7. In most of the practical situations, group velocity is higher than the particle velocity.
8. Due to nuclear motion, all energy levels of hydrogen are increased by a very small fraction.
9. The wave function is a measurable quantity.
10. An electron in an orbit does not radiate energy.

(10 × 1 = 10 marks)

Section B

Answer all questions in two or three sentences.

Each question carries 2 marks.

11. Draw the spectrum of a blackbody and indicate the regions obeying Raleigh-Jeans law and Wien's law.
12. Write down the Einstein photoelectric equation. What are the terms involved ?
13. What are de Broglie waves ? Give an expression for the de Broglie wavelength.
14. What is the basic working principle of an electron microscope ?

Turn over

15. What do you mean by the Bohr radius of a hydrogen atom? Write down the expression for the radius of orbits in terms of the Bohr radius.
16. What do you mean by the term zero point energy of a quantum harmonic oscillator? What is its value?
17. Illustrate the Pauli's exclusion principle.

(7 × 2 = 14 marks)

Section C

Answer any five questions in a paragraph of about half a page to one page.
Each question carries 4 marks.

18. Explain the pair production phenomenon. Does it violate any conservation law? Is it possible for pair production to occur in free space?
19. What is gravitational red shift? Obtain an expression for the relative frequency change.
20. Discuss the energy-time uncertainty principle. Does uncertainty exist in classical mechanics?
21. What are the purpose of Franck-Hertz experiment? Draw the schematic of Franck-Hertz experiment setup and indicate the parts.
22. Using suitable figures, explain the origin of emission and absorption lines of atoms.
23. Discuss the essential conditions on a wavefunction.
24. Explain the normal Zeeman effect.

(5 × 4 = 20 marks)

Section D

Answer any four questions.
Each question carries 4 marks.

Problems write all relevant formulas, all important steps carry separate marks.

25. Light of wavelengths 3125 Å and 3650 Å causes the emission of electrons having kinetic energies 2.128 eV and 1.595 eV respectively from sodium. Determine the value of Planck's constant from this data.
26. Estimate the de Broglie wavelength of an electron which is accelerated through a potential difference of 100 V.
27. The average period that elapses between the excitation of an atom and the time it emits radiation is 10^{-8} s. Determine the width of the excited state.
28. Determine the wavelength of the photon required to ionize a hydrogen atom in the ground state and gives the ejected electron a kinetic energy of 10.5 eV.
29. Find the expectation value of the momentum of a particle enclosed in a one-dimensional box.
30. Electron with energy 1 eV is incidence on a barrier of height 10 eV and width 0.5 nm. Find the transmission probability.
31. Compare the angular momentum of a ground state electron in the Bohr model of the hydrogen atom with its value in the quantum theory.

(4 × 4 = 16 marks)

Section E (Essays)

*Answer any two questions in about two pages.
Each question carries 10 marks.*

32. What is the importance of Compton effect ? Obtain an expression for the change in wavelength of a Compton scattered photon.
33. What are the essential features of Bohr atom model ? Discuss the origin of the spectral series of hydrogen.
34. Discuss qualitatively the tunnel effect observed in case of a particle approaching a potential barrier of finite width, with kinetic energy less than the barrier height.
35. Explain the quantum numbers associated with hydrogen atom. What are their values ? Explain the significance of the quantum numbers.

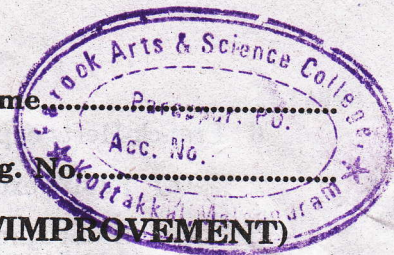
(2 × 10 = 20 marks)

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(Pages : 3)

Name.....

Reg. No.....



**FIFTH SEMESTER B.Sc. DEGREE (SUPPLEMENTARY/IMPROVEMENT)
EXAMINATION, NOVEMBER 2016**

(UG—CCSS)

Physics

PH 5B 10—QUANTUM MECHANICS

(2013 Admissions)

Time : Three Hours

Maximum : 30 Weightage

I. Objective questions (Answer *all* questions) :

1 The low frequency limit to Planck's law is :

- (a) Wien's law. (b) Rayleigh-Jeans law.
(c) Newton's law. (d) Boyle's law.

2 Compton effect confirms :

- (a) Wave nature of radiation. (b) Particle nature of radiation.
(c) Particle nature of matter. (d) Wave nature of matter.

3 Photons possess :

- (a) Gravitational mass only.
(b) Rest mass only.
(c) Both gravitational and rest mass.
(d) No mass at all.

4 Electron microscopes employ :

- (a) Particle nature of protons. (b) Wave nature of protons.
(c) Particle nature of electrons. (d) Wave nature of electrons.

5 When the number of waves forming a wave packet is increased, what happens to the width of the wave packet ?

- (a) Becomes wider. (b) Becomes narrower.
(c) Becomes zero. (d) Becomes infinity.

Turn over

- 6 Franck-Hertz experiment confirms :
- (a) Pauli's exclusion principle.
 - (b) De Broglie hypothesis.
 - (c) Discreteness of atomic energy levels.
 - (d) Spin of electron.
- 7 The quantum mechanical operator for energy is _____.
- (a) $-i\hbar \frac{\partial}{\partial x}$
 - (b) $i\hbar \frac{\partial}{\partial x}$
 - (c) $-i\hbar \frac{\partial}{\partial t}$
 - (d) $i\hbar \frac{\partial}{\partial t}$
- 8 Among the following, which system has energy levels equally spaced ?
- (a) Hydrogen atom.
 - (b) Particle in a box.
 - (c) Harmonic oscillator.
 - (d) Rigid rotator.
- 9 The magnetic quantum number is related to the conservation of :
- (a) Mass.
 - (b) Angular momentum magnitude.
 - (c) Angular momentum direction.
 - (d) Energy.
- 10 For the principal quantum number 3, which among the following is a possible value for the orbital angular momentum quantum number ?
- (a) 0.
 - (b) 1.
 - (c) 2.
 - (d) 3.
- 11 The space-quantization of electron spin was first demonstrated by _____ experiment.
- 12 The momentum expectation value of a particle enclosed in a box is _____.

(12 × ¼ = 3 weightage)

II. Short answer questions (Answer *all* questions) :

- 13 Draw the spectrum of a black body.
- 14 What is gravitational red shift ?
- 15 Discuss the probability interpretation of the wavefunction.
- 16 Explain the terms phase velocity and group velocity.
- 17 What are the basic postulates in Bohr's atom model ?

- 18 Discuss the effect of nuclear mass on the atomic spectral lines.
- 19 What are the essential conditions on a wavefunction ?
- 20 What do you mean by the term zero point energy of a harmonic oscillator ?
- 21 State Pauli's exclusion principle.

(9 × 1 = 9 weightage)

III. Short essay questions (Answer any *five* questions) :

- 22 X-rays of wavelength 10 p.m. are Compton scattered from a metal block. Determine the maximum wavelength present in the scattered rays.
- 23 Determine the de Broglie wavelength of an electron accelerated through a potential difference of 100 V.
- 24 An eigen function of the operator $\frac{d^2}{dx^2}$ is e^{2x} . Find the corresponding eigen value.
- 25 A particle moving in one dimension has the wavefunction $\psi = ax^2$ in the interval $x = 0$ and $x = 1$ and zero elsewhere. Find the expectation value of the position of the particle.
- 26 Compare a quantum mechanical harmonic oscillator to its classical counterpart.
- 27 A proton in a one-dimensional box has energy 400 keV in its first excited state. Determine the width of the box.
- 28 Explain normal Zeeman effect.

(5 × 2 = 10 weightage)

IV. Essay questions (Answer any *two* questions) :

- 29 What is photoelectric effect ? Discuss the experimental findings and give Einstein's explanations.
- 30 Discuss the Bohr's theory of hydrogen atom and explain the various spectral series.
- 31 Discuss the theory of quantum mechanical tunneling.

(2 × 4 = 8 weightage)

FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2015

(U.G.—CCSS)

Core Course—Physics

PH 5B 10—QUANTUM MECHANICS

(2013 Admissions)

Time : Three Hours

Maximum : 30 Weightage

I. Objective questions. Answer *all* questions :

1 The speed of electromagnetic waves in free space is given by :

(a) $\mu_0 \epsilon_0$.

(b) $\sqrt{\mu_0 \epsilon_0}$.

(c) $\frac{1}{\sqrt{\mu_0 \epsilon_0}}$.

(d) $\frac{1}{\mu_0 \epsilon_0}$.

2 In photoelectric effect, what is the slope of the maximum photoelectron-kinetic energy versus incident frequency curve ?

(a) Planck's constant.

(b) Work function.

(c) Charge of electron.

(d) Mass of electron.

3 In pair production, a photon materializes into :

(a) Electron and neutron.

(b) Electron and photon.

(c) Electron and proton.

(d) Electron and positron.

4 Davisson Germer experiment confirms :

(a) Particle behavior of electrons. (b) Wave behavior of protons.

(c) Particle behavior of protons. (d) Wave behavior of electrons.

5 When the number of waves forming a wave packet is increased, what happens to the width of the wave packet ?

(a) Becomes wider.

(b) Becomes narrower.

(c) Becomes zero.

(d) Becomes infinity.

6 Which spectral series of hydrogen falls in the visible region of the electromagnetic spectrum ?

(a) Lyman.

(b) Balmer.

(c) Paschen.

(d) Brackett.

Turn over

7 The quantum mechanical operator for momentum is :

(a) $-i\hbar \frac{\partial}{\partial x}$.

(b) $i\hbar \frac{\partial}{\partial x}$.

(c) $-i\hbar \frac{\partial}{\partial t}$.

(d) $i\hbar \frac{\partial}{\partial t}$.

8 Among the following, which system has energy levels equally spaced :

(a) Hydrogen atom.

(b) Particle in a box.

(c) Harmonic oscillator.

(d) Rigid rotator.

9 The principal quantum number is related to the conservation of :

(a) Mass.

(b) Angular momentum magnitude.

(c) Angular momentum direction.

(d) Energy.

10 For the principal quantum number 2, which among the following is a possible value for the orbital angular momentum quantum number ?

(a) 1.

(b) 2.

(c) 3.

(d) 4.

11 Stern-Gerlach experiment demonstrates the _____ of electron spin.

12 For a particle in a box, the expectation value of momentum is _____.

(12 × ¼ = 3 weightage)

II. Short answer questions. Answer *all* questions :

13 What do you mean by ultraviolet catastrophe ?

14 What is the origin for the incident wavelength component in the Compton spectrum ?

15 Discuss the probability interpretation of the wavefunction.

16 Explain the terms phase velocity and group velocity.

17 What is Bohr's correspondence principle ?

18 What do you mean by the term ionization energy of an atom ?

19 What are the essential conditions on a wavefunction ?

20 Write down the expression for the energy eigen values of a harmonic oscillator.

21 Why is only one component of electron's angular momentum quantized ?

(9 × 1 = 9 weightage)

III. Short essay questions. Answer any *five* questions :

22 X-rays of wavelength 5 pm are Compton scattered from a target. Determine the minimum and maximum wavelength of the scattered X-rays.

23 Calculate the de Broglie wavelength of an electron having a kinetic energy 1000 eV.

24 An eigen function of the operator $\frac{d^2}{dx^2}$ is e^{2x} . Find the corresponding eigen value.

- 25 A particle moving along the x -direction has the wavefunction $\psi = ax$ in the interval $x = 0$ and $x = 1$ and zero elsewhere. Determine the probability that the particle can be found between $x = 0.4$ and $x = 0.6$.
- 26 Compare a quantum mechanical harmonic oscillator to its classical counterpart.
- 27 An electron is enclosed in a box of length 1 \AA . Determine the energy eigen values.
- 28 Discuss the selection rules for radiative transitions.

(5 × 2 = 10 weightage)

IV. Essay questions. Answer any *two* questions :

- 29 Explain de Broglie hypothesis. Discuss the Davisson-Germer experiment.
- 30 Explain the Bohr's theory of hydrogen atom and discuss the spectral series.
- 31 Set up the time-dependent Schrödinger equation and discuss the steady-state case.

(2 × 4 = 8 weightage)

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(Pages : 4)

Name.....

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FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2014

(U.G.-CCSS)

Core Course—Physics/Applied Physics

PH 5B 10/AP 5B 12—QUANTUM MECHANICS

Time : Three Hours

Maximum : 30 Weightage

Section A

Answer all questions.

1. Photoelectric phenomenon was first explained by :
 - (a) Bohr.
 - (b) Millikan.
 - (c) Einstein.
 - (d) Planck.
2. Neglecting relativistic change of mass, the wavelength associated with an electron of kinetic energy E is proportional to :
 - (a) $E^{1/2}$.
 - (b) $E^{-1/2}$.
 - (c) E .
 - (d) E^{-1} .
3. The phase velocity (v_p) and group velocity (v_g) of a de-Broglie wave in free space are related as :
 - (a) $\frac{v_p}{v_g} = \sqrt{2}$.
 - (b) $v_p v_g = c^2$.
 - (c) $\frac{v_p}{v_g} = 0.5$.
 - (d) $v_p v_g = \sqrt{2}c^2$.
4. Of the following moving with the same velocity, the one which has largest wavelength is :
 - (a) An electron.
 - (b) A proton.
 - (c) A neutron.
 - (d) An α -particle.
5. The existence of matter waves is confirmed by :
 - (a) Sten-Gerlach experiment.
 - (b) Frank-Hute experiment.
 - (c) Millikan's oil drop experiment.
 - (d) Davidson and Germer experiment.

Turn over

6. The allowed energy values of a particle in a box of length L are given by :

(a) $\frac{n^2 \pi^2 \hbar^2}{mL^2}$

(b) $\frac{n^2 \pi^2 \hbar^2}{2mL^2}$

(c) $\frac{\pi^2 \hbar^2}{2mL^2 n^2}$

(d) $\frac{n \pi \hbar}{2mL}$

7. The Bohr's quantisation condition is :

(a) $L = \frac{nh}{2\pi}$

(b) $L = nh$

(c) $L = -nh$

(d) $L = \frac{-nh}{2\pi}$

8. The quantity $|\psi|^2$ represents :

(a) Probability density.

(b) Change density.

(c) Energy density.

(d) Wave intensity.

9. The momentum operator in quantum mechanics is :

(a) $\frac{\hbar}{i} \nabla$

(b) $-\hbar \nabla$

(c) $\frac{i}{\hbar} \nabla$

(d) $\frac{i}{\hbar^2} \nabla$

10. For normalised wave function the value of $\int_{-\infty}^{+\infty} \psi_m^* \psi_m d\tau$ is :

(a) 0.

(b) 1.

(c) -1.

(d) ∞ .

11. The energy levels of harmonic oscillator according to Schrödinger's equation is :

(a) $n \hbar \omega$

(b) $\left(n + \frac{1}{2}\right) \hbar \omega$

(c) $\frac{\hbar \omega}{\left(n + \frac{1}{2}\right)}$

(d) $(n^2 - 1) \hbar \omega$

12. The expectation value of potential energy in hydrogen atom is :
- (a) 13.6 eV. (b) Zero.
(c) -13.6 eV. (d) -27.2 eV.

(12 × ¼ = 3 weightage)

Section B*Answer all questions.*

13. Show that for a non-relativistic free particle, the phase velocity is half the group velocity.
14. What is meant by normalised and orthogonal wave functions ?
15. What are eigenvalues and eigenfunctions ?
16. Explain Zeeman effect.
17. Write Schrödinger's time-independent wave equation.
18. What is Compton effect ?
19. What is zero point energy ?
20. Explain any *one* application of Heisenberg's uncertainty principle.
21. State the postulates of quantum mechanics.

(9 × 1 = 9 weightage)

Section C*Answer any five questions.*

22. The average lifetime of hydrogen in excited state is 2.5×10^{-14} s, calculate the uncertainty in the measurement of energy in this state.
23. Calculate the energy difference between the ground state and the first excited state for an electron in one-dimensional rigid box of length 10^{-10} m (mass of electron = 9.1×10^{-31} kg and $h = 6.63 \times 10^{-34}$ Js).
24. A particle is in motion along a line between $x = 0$ and $x = a$ with zero potential energy, and at points for which $x < 0$ and $x > a$ the potential energy is infinite. The wave function for the particle in the n^{th} state is given by :

$$\psi_n = A \sin \frac{n\pi x}{a}. \text{ Find the expressions for the normalized wave functions.}$$

25. Calculate the wave of Bohr magneton. Given $e = 1.6 \times 10^{-19}$ C, $h = 6.62 \times 10^{-34}$ J_s, $m = 9.11 \times 10^{-31}$ kg.
26. What voltage must be applied to an electron microscope to produce electrons of wavelength of 0.5 \AA ? Given $e = 1.6 \times 10^{-19}$ C, $m = 9 \times 10^{-31}$ kg, $h = 6.62 \times 10^{-34}$ Js.

Turn over

27. Calculate the energy and momentum (in eV) of an X-ray photon of wavelength 2 \AA .
28. Calculate the work function in electron volt for sodium metal given that photoelectric threshold wavelength is 6800 \AA .

(5 × 2 = 10 weightage)

Section D

Answer any two questions.

29. Obtain Schrödinger wave equation for a particle in one-dimensional rigid box. Solve it to obtain eigenfunctions and show that eigenvalues are discrete.
30. (a) Derive time dependent Schrödinger equation.
(b) Explain the physical significance of wave function.
31. Describe the Stern-Gerlach experiment for verification of space quantization.

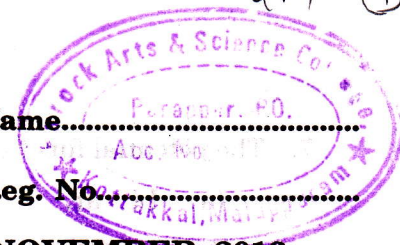
(2 × 4 = 8 weightage)

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(Pages : 4)

Name.....

Reg. No.....



FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2013

(UG—CCSS)

Physics—Core Course

PH 5B 10 / AP 5B 12—QUANTUM MECHANICS

(Common for Applied Physics)

Time : Three Hours

Maximum : 30 Weightage

Section A

Answer all questions.

1. Matter waves

- (a) Are longitudinal. (b) Are electromagnetic.
(c) Always travel with speed of light. (d) Show diffraction.

2. According to Schrödinger, a particle is equivalent to a :

- (a) Single wave. (b) Wave-packet.
(c) Light wave. (d) Cannot behave as wave.

3. The uncertainty relation cannot hold for the following pairs :

- (a) Position and momentum. (b) Energy and time.
(c) Linear momentum and angle. (d) Angular momentum and angle.

4. A particle possesses discrete energy levels :

- (a) In free space. (b) In a box of rigid walls.
(c) Both (a) and (b). (d) Neither (a) nor (b).

5. The allowed energy values of a particle in box of length L are given by :

- (a) $\frac{n^2 \pi^2 \hbar^2}{mL^2}$. (b) $\frac{n^2 \pi^2 \hbar^2}{2mL^2}$.
(c) $\frac{\pi^2 \hbar^2}{2mL^2 n^2}$. (d) $\frac{n\pi\hbar}{2mL}$.

6. The energy operator is :

- (a) $\frac{\hbar}{i} \frac{\partial}{\partial t}$. (b) $i \hbar \frac{\partial}{\partial t}$.
(c) $\frac{\hbar}{i} \nabla$. (d) $i \hbar \nabla$.

Turn over

7. The potential function of harmonic oscillator is :

- (a) Linear. (b) Parabolic.
(c) Elliptical. (d) Hyperbolic.

8. When a particle of energy $E < V_0$ is incident on a potential barrier of height V_0 , then the probability of penetration is :

- (a) Zero. (b) 1.
(c) Finite. (d) Infinite.

9. The energy levels of harmonic oscillator according to Schrödinger's equation is :

- (a) $n\hbar\omega$. (b) $\left(n + \frac{1}{2}\right)\hbar\omega$.
(c) $\frac{\hbar\omega}{\left(n + \frac{1}{2}\right)}$. (d) $\left(n^2 - 1\right)\hbar\omega$.

10. Of the following having the same kinetic energy, which has the longest wavelength :

- (a) An electron. (b) Proton.
(c) Neutron. (d) α -particle.

11. For orthogonal wave functions, the value of $\int \psi_m^* \psi_n dx$ is :

- (a) 1. (b) 0.
(c) ∞ . (d) -1.

12. The waves associated with electrons are called :

- (a) Light waves. (b) Sound waves.
(c) Matter waves. (d) Transverse waves.

(12 × ¼ = 3 weightage)

Section B

Answer all questions.

13. State the principle of superposition of waves.
14. State the postulates of quantum mechanics.
15. Explain uncertainty principle.

16. What is electron spin hypothesis.
17. What do you mean by tunnelling through a barrier ?
18. Explain the significance of wave function.
19. What is correspondence principle ?
20. Distinguish between phase velocity and group velocity.
21. Write Schrödinger's time dependent wave equation.

(9 × 1 = 9 weightage)

Section C*Answer any five questions.*

22. Find the change in wavelength of an X-ray photon when it is scattered through an angle of 90° by a free electron.
23. What voltage must be applied to an electron microscope to produce electrons of wavelength 1Å .
24. Find the normalisation constant of a particle constrained to move in an one dimensional infinite potential well of width L , such that $0 \leq x \leq L$, whose wave function is $\psi_x = A \sin\left(\frac{n\pi x}{L}\right)$, where n is an integer.
25. Calculate the total energy of the electron in the first Bohr orbit, in electron Volt. (Given electron rest mass $m = 9.11 \times 10^{-31}$ kg, electron charge $e = 1.6 \times 10^{-19}$ C, Planck's constant $h = 6.63 \times 10^{-34}$ Js), permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12}$ C²/Nm² and $1\text{eV} = 1.6 \times 10^{-19}$ J)
26. An electron has a speed of 300 m/s accurate to 0.01 %. With what fundamental accuracy can we locate the position of the electron ?
27. Calculate the value of Bohr radius.
28. Calculate the de Broglie wavelength of neutrons of Kinetic energy 1eV.

(5 × 2 = 10 weightage)

Section D*Answer any two questions.*

29. What is a wave function ? Derive Schrödinger's time Independent equation.
30. Describe Davisson and Gerner experiment for the study of diffraction of electrons and show that the results of this experiment are closely in agreement with de-Broglie wavelength of electrons.

Turn over

- 31. (a) Write the time-independent Schrödinger wave equation for the hydrogen atom in spherical polar co-ordinates and separate it into three differential equations for the three parts of the total wave-function.
- (b) Solve the azimuthal wave function and show that the magnetic quantum number m_l must be zero or a positive or negative integer.

(2 x 4 = 8 weightage)

Answer any five questions

- 22. Find the change in wavelength of an X-ray photon when it is scattered through an angle of 90° by a free electron.
- 23. What voltage must be applied to an electron microscope to produce electrons of wavelength 1 Å?
- 24. Find the normalisation constant of a particle constrained to move in an one dimensional infinite potential well of width L , such that $0 \leq x \leq L$, whose wave function is $\psi = A \sin\left(\frac{n\pi x}{L}\right)$, where n is an integer.

- 25. Calculate the total energy of the electron in the first Bohr orbit in electron Volt. (Given electron rest mass $m = 9.11 \times 10^{-31}$ kg, electron charge $e = 1.6 \times 10^{-19}$ C, Planck's constant $h = 6.63 \times 10^{-34}$ Js, permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12}$ C²/Nm² and $1\text{eV} = 1.6 \times 10^{-19}$ J)
- 26. An electron has a speed of 300 m/s accurate to 0.01%. With what fundamental accuracy can we locate the position of the electron?

- 27. Calculate the value of Bohr radius.
- 28. Calculate the de Broglie wavelength of neutrons of kinetic energy 1 eV.

(2 x 5 = 10 weightage)

Section D

- 29. What is a wave function? Derive Schrödinger's time independent equation.
- 30. Describe Davisson and Germer experiment for the study of diffraction of electrons and show that the results of this experiment are closely in agreement with de Broglie wavelength of electrons.

Turn over