E – 1834

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Reg. No. : .....

Name : .....

Sixth Semester B.Sc. Degree Examination, April 2018
Career Related First Degree Programme Under CBCSS
Physics with Computer Applications
Core Course
PC 1642 : QUANTUM MECHANICS
(2014 Admission)

Time : 3 Hours

Max. Marks : 80

SECTION – A

Answer **all** questions in **one** or **two** sentences. **Each** question carries **one** mark.

1. Give Planck's distribution law for blackbody radiation.
2. What is meant by threshold frequency of photoelectric emission ?
3. Write down the time-dependent Schrodinger equation.
4. Give the expressions for position and momentum operators in one-dimensional space.
5. Is the wave function of a free particle with definite energy normalizable ? Why ?
6. Distinguish between phase velocity and group velocity.
7. Give the energy levels of a particle confined in an infinite square well.
8. Define Dirac delta function.
9. Explain transmission coefficient in connection with a finite potential well.
10. What is scattering matrix ?

(10×1=10 Marks)

SECTION – B

Answer **eight** questions **not** exceeding a paragraph. **Each** question carries **two** marks.

11. Show that, in the low frequency limit, Planck's law gives Rayleigh-Jean's law.
12. Describe how Einstein's photoelectric equation explains the laws of photoelectric effect.

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13. Briefly explain the Bohr atom model.

14. What is meant by expectation value of an observable ? Give expectation values of position and momentum.

15. Discuss the correspondence principle.

16. Define probability current density. What is its value when the wave function is real ?

17. State and explain Heisenberg's uncertainty principle.

18. Distinguish between a bound state and a scattering state.

19. Explain quantum mechanical tunneling.

20. Explain orthogonality of wave functions with examples.

21. What is zero point energy of a harmonic oscillator ? Discuss how it originates from the uncertainty principle.

22. Explain symmetric (even) and anti-symmetric (odd) wave functions using the bound state solutions of a particle moving in a square potential well.

(8×2=16 Marks)

SECTION – C

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

Useful data : Planck's constant $h = 6.626 \times 10^{-34}$ Js;

mass of the electron $m = 9.1 \times 10^{-31}$ kg ; charge of the electron $e = 1.6 \times 10^{-19}$C.

23. Find the frequency and wavelength corresponding to a photon of energy 1keV.

24. Threshold frequency for photo electric emission in copper is 1.1×10^{15} Hz. Find the maximum kinetic energy of photoelectrons emitted when a radiation of frequency 1.5×10^{15} Hz strikes the copper surface.

25. Find the de Broglie wavelengths of (a) 46g golf ball with speed 3 m/s. (b) electron moving with a speed of 10^6 m/s.

26. Normalize the wave function $\psi(x) = e^{-\frac{\alpha^2 x^2}{2}}$ where α is a constant. Use $\int_{-\infty}^{\infty} e^{-ax^2} = \sqrt{\frac{\pi}{a}}$.

27. The ground state energy of a particle confined in an infinite square well potential is 34 eV. Find the energy of the particle in the first two excited levels.

28. Calculate the ground state energy of a harmonic oscillator vibrating with a frequency of 5×10^{14} Hz.

29. Calculate the expectation value of position in the ground state of a particle confined in an infinite potential well located in the region $0 \leq x \leq L$.

30. An electron is held in a square potential well of width 1×10^{-10} m. Find the possible values of the well's depth V_0 such that there is exactly one bound energy state of the electron.

31. Determine the group velocity V_g and phase velocity V_{ph} associated with a free particle of mass m moving with a velocity v. (use non-relativistic relation)

(6×4=24 Marks)

SECTION – D

Answer **any two** questions. **Each** question carries **fifteen** marks.

32. Discuss the theory of the Compton effect and describe the experimental observations.

33. Discuss the statistical interpretation of the wave function. Describe the normalization of a wave function and show that it is independent of time.

34. From the time-dependent Schrodinger equation, deduce the time-independent Schrodinger equation. Discuss the general features of stationary states.

35. Obtain the energy eigenvalues of a simple harmonic oscillator. **(2×15=30 Marks)**

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Sixth Semester B.Sc. Degree Examination, April 2019
Career Related First Degree Programme under CBCSS
PHYSICS WITH COMPUTER APPLICATIONS
Core Course
PC 1642 : Statistical Mechanics and Quantum Mechanics
(2015 Admission Onwards)

Time : 3 Hours

Max. Marks : 80

SECTION – A

Answer **all** the questions : **(10×1=10 Marks)**

1. What is the nature of the particles which can be treated with B.E. Statistics ?
2. Why the photo electrons do not have as much energy as the quantum of light which cases its ejection ?
3. Give the characteristics of Black body radiation.
4. What do you mean by tree particle and bound particle ?
5. What is degeneracy ?
6. Is M.B. – Statistics applicable to electron gas ?
7. Which Statistics is followed by the following particles ?
   Electron, ideal gas molecules, proton, photon, helium atom, neutron, π meson, μ meson ?
8. Both photoelectric and Compton effects arise due to the action of photons on electrons, but the two effects are not the same. Explain this.
9. What do you understand by the terms Eigen value and Eigen function ?
10. State the correspondence principle.

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SECTION – B

(8×2=16 Marks)

Answer **any 8** questions :

11. Explain Micro-Canonical ensemble.
12. Can a particle with zero energy exist in the box ? What is zero point energy ?
13. What are Micro and Macro States ?
14. What do you mean by Stationary States ?
15. Obtain the relation between entropy and thermodynamic probability.
16. Distinguish Canonical ensemble and grand canonical ensemble.
17. Explain normalization of wave function.
18. What are the basic differences between Wien's law and Reyleigh-Jeans law of blackbody radiation ?
19. Explain why an electron in Compton effect cannot be scattered at an angle greater than 90°.
20. Compare MB, BE and FD Statistics mentioning at least three characteristics.
21. State Bohr postulates.
22. Write the properties of a Wave function.

SECTION – C

Answer **any six** questions : **(6×4=24 Marks)**

23. The work function of a metal is 3.45 eV. Find the maximum wavelength of photon that can eject an electron from the metal.
24. The life time of a typical excited state of an atom is 1×10^{-8} sec. The atom emits a photon of wavelength 6000 A°. What is the energy uncertainty of this photon ? What is the wavelength uncertainty of this photon ?
25. Obtain Schrodinger time dependent equation.

26. A particle trapped is one dimensional infinite potential well of width L is given by $\psi = A\,Sin\left(\frac{n\pi x}{2}\right)$ in the region : $\begin{cases} x > 0 \\ x < L \end{cases}$. Find the normalization constant A.

27. Find out the possible arrangements of two particles A and B in three cells according to MB-Statistics.

28. Estimate the maximum error in the determination of velocity of an electron if it is constrained to more in the X-direction and if its X-coordinate is known with an uncertainty of 10^{-6} m.

29. Obtain the energy of electron in a Bohr orbit.

30. The photoelectric threshold for a metal is 3000 Å. Find the K·E of an electron ejected from it by radiation of wavelength 1200 Å.

31. X-rays of wavelength 1.0 Å are scattered from a carbon block. Find the wavelength of the scattered beam in a direction making 90° with the incident beam. What is the K-E of the recoiling electron ? Given $h = 6.63 \times 10^{-34}$ J-S, $e = 3 \times 10^{8}$ m/sec. and $1ev = 1.6 \times 10^{-19}$ J.

SECTION – D

Answer **any two** questions : **(2×15=30 Marks)**

32. Explain the phenomenon of BE – condensation and show graphically how the condensate fraction varies with temperature ?

33. What is photoelectric effect ? Give an account of Einstein's explanation of photoelectric effect on the basis of quantum theory.

34. Give an account of Heisenberg uncertainty principle. Outline an idealised experiment to bring out its significance.

35. Setup Schrodinger wave equation for a linear harmonic oscillator. Solve the equation and obtain its energy eigen values. Also deduce its zero point energy.
