Total No. of Questions: 6 *Total No. of Printed Pages:3*

Enrollment No.....

Faculty of Science

End Sem (Odd) Examination Dec-2022

BC3EP04 Quantum Mechanics & Spectroscopy

Programme: B.Sc. Branch/Specialisation: Computer Science

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

Q.1 i. In the Compton scattering, the increase in wavelength depends on- **1**

(a) The Wavelength of the incident radiation
(b) Nature of scatterer
(c) Angle of scattering
(d) None of these

ii. The velocity of matter wave is- **1**

(a) c (b) v (c) c^2/v (d) c/v

iii. The Quantity $|\Psi|^2$ represents- **1**

(a) Probability density (b) Charge density
(c) Energy density (d) Intensity of wave

iv. The wave function associated with a material particle is- **1**

(a) Only finite
(b) Only continuous
(c) Only single valued
(d) Finite, single valued and continuous

v. The expectation value of potential energy of hydrogen atom is- **1**

(a) Zero (b) -13.6 eV (c) -27.2 eV (d) 13.6 eV

vi. A particle of energy E is incident on a potential step of finite width and height V_0. If $E \leq V_0$, then- **1**

(a) R=0, T=1 (b) R=1, T=0
(c) R=0.5, T=0.5 (d) R=0.16, T=0.84

vii. The values of L, S and J in the ground state of sodium atom are- **1**

(a) L=0, S=1/2, J=1/2 (b) L=0, 1,2 S=1, J=3,2,1
(c) L=1, S=1/2, J=1/2,3/2 (d) L=2, S=1/2, J=3/2

P.T.O.

viii. The maximum number of electrons in a shell of principal quantum number n is- **1**
(a) 2 (b) 2n (c) $2n^2$ (d) 8

ix. The mass number of a nucleus is equal to- **1**
(a) The number of electrons in it
(b) The number of protons in it
(c) The number of neutrons in it
(d) The number of nucleons in it

x. Nuclear forces are- **1**
(a) Gravitational attractive
(b) Electrostatic repulsive
(c) Long range and strong attractive
(d) Short range and strong attractive

Q.2 i. Write four differences between electromagnetic waves and matter waves. **2**

ii. What is photoelectric effect? Write down the photoelectric equation and explain the meaning of symbols used. **3**

iii. Define phase velocity and group velocity and establish relation between them. **5**

OR iv. Explain Heisenberg's uncertainty principle and derive it. **5**

Q.3 i. Write the four properties of wave function. **2**

ii. Derive time dependent and time independent wave equation. **8**

OR iii. A particle of mass m is enclosed in a one-dimensional box of length l. Show that the energy of a particle in a box is given by the following relation: $En = n^2h^2/8ml^2$. **8**

Q.4 i. Write the energy Eigen values and the Schrödinger's equation for a linear harmonic Oscillator. Draw the diagram for its energy levels. **3**

ii. Write down the Schrödinger wave equation for the particle incident on a rectangular potential barrier and solve it. **7**

OR iii. Show that the degeneracy of n^{th} energy state of hydrogen atom is $2n^2$. **7**

Q.5 i. Deduce energy of electron in n^{th} orbit. **4**

ii. Explain the fine structure of H_α line on the basis of vector atom model. **6**

OR iii. What is meant by L-S coupling? Give example. **6**

Q.6 Attempt any two:

i. What is binding energy? Draw the binding energy curve? What important information do you obtain from the binding energy curve? **5**

ii. Discuss shell model. **5**

iii. Explain the working of cyclotron with neat diagram and give its limitations. **5**

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Marking Scheme(BC3EP04 Quantum Mechanics and Spectroscopy)

i. In the Compton Scattering, the increase in Wavelength depends on: **1**

(c) Angle of scattering

ii The velocity of matter wave is: **1**

(b) c^2/v

iii The Quantity $|\Psi|^2$ represents: **1** **1**

(a) Probability density

iv The wave function associated with a particle is: **1**

(d)Finite, continuous and single valued

v The expectation value of potential energy of hydrogen atom is: **1**

(c) -27.2 eV

vi A particle of energy E is incident on a potential step of finite width and height V_0. If $E \leq V_0$, then: **1**

(b) R=1, T=0

vii The values of L, S and J in the ground state of sodium atom are: **1** **1** (b)L=0, S=1/2, J=1/2

viii The maximum number of electrons in a shell of principal quantum number n is: **1** (b) $2n^2$

ix The mass number of a nucleus is equal to: **1**

(d) The number of nucleons in it

x Nuclear forces are: **1**

(d) Short range and strong attractive

Q. 2 i) Write four differences between Electromagnetic waves and matter Waves. **2 marks**

0.5 mark for each (0.5 mark * 4=2)

ii) Definition of Photoelectric effect. **1.5 marks**

Explanation of the photoelectric equation. **1.5 marks**

iii) Definition of v_p & v_g. **1 mark**

Relation between v_p & v_g. **4 marks**

iv) Statement of Heisenberg's uncertainty principle. **1 mark**

Derivation for Heisenberg's uncertainty principle. **4 marks**

Q.3 i) Four properties of wave function. **2 marks**

0.5 mark for each (0.5 mark * 4=2)

ii) Basic postulates of Quantum mechanics. **8 marks**

iii) Full derivation for energy of the particle. **8 marks**

Q.4 i) Energy Eigen values and the Schrödinger's equation for a linear harmonic Oscillator. **1 mark**

Diagram of energy levels. **2 marks**

ii) Schrödinger wave equation for the particle incident on a rectangular potential barrier and its solution **7 marks**

iii) Show that the degeneracy of n^{th} energy state of hydrogen atom is $2n^2$. **7 marks**

Q.5 i) Derivation for electron's energy in n^{th} orbit. **4 marks**

ii) Fine structure of H_α line on the basis of vector atom model **6 marks**

iii) Meaning of L-S coupling. **2 marks**

Explanation with example. **4 marks**

Q.6 i) What is binding energy? **1mark**

Draw the binding energy curve? **2 marks**

What important information do you obtain from the binding energy curve? **2 marks**

ii) Discussion of shell model. **5 marks**

iii) Cyclotron diagram. **1 mark**

Cyclotron working. **4 marks**