K23P 1426

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (C.B.S.S. – Reg./Supple./Imp.)
Examination, October 2023
(2020 Admission Onwards)
PHYSICS
PHY3E 02 : Radiation Physics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** the questions. (Either **a** or **b**).

I. a) Discuss Compton scattering and pair production interaction mechanisms of gamma rays. In a Compton scattering experiment, X-rays of wavelength 0.015 Å is scattered at 60°. Find the wavelength of the scattered X-rays.

OR

b) Discuss various types of dosimeters, giving their basic principle and the uniqueness of each.

II. a) Discuss the different types of radiations. Also explain the different natural radioactive sources.

OR

b) Discuss the effects of ionizing radiation at molecular and cellular levels.

(2×12=24)

SECTION – B

Answer **any four** questions. (**1** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**)

III. a) What is elastic scattering ?

b) What do you mean by LET ? Explain.

c) What are linear and mass absorption coefficients ? How are they related to each other ?

P.T.O.

IV. a) What is mutation ?

b) Distinguish between deterministic and stochastic effects of radiation.

c) Explain in detail the genetic effects of radiation.

V. a) What is stopping power of alpha particles ?

b) How is stopping power and range of alpha particles related ?

c) Explain the interaction of heavy charged particles with matter.

VI. a) What do you mean by particle fluence ?

b) A narrow beam of 100 MeV neutrons, with a fluence of $10^5 n/cm^2/sec$, is normally incident on an aluminum [$_{13}Al^{27}$] plate. The elastic scattering cross section of aluminum for 100 MeV neutrons is 0.95 barns. The density of aluminum is 2.7 g/cm^3. How thick must the aluminum plate be in order to reduce the number of unscattered neutrons emerging from the plate by three orders of magnitude ?

c) Explain KERMA. Discuss collision KERMA and radiative KERMA.

VII. a) What are the different naturally occurring radioactive sources ?

b) Briefly explain the different artificial sources of radioactivity.

c) Explain the principle of cyclotron with a neat labelled diagram.

VIII. a) What is ALARA ?

b) Explain the three principles of ALARA.

c) Explain the shielding of beta and gamma rays. **(4×9=36)**

———————

K22P 1426

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (CBSS – Reg./Sup./Imp.) Examination, October 2022
(2019 Admission Onwards)
PHYSICS
PHY3E02 : Radiation Physics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (either **a** or **b**). **(2×12=24)**

1. a) Explain the effects of radiation on chromosomes. What are genetic effects ?

   OR

   b) Explain the principle and working of nuclear reactor. Mention its uses.

2. a) What are different electron sources ? Explain how they are produced.

   OR

   b) Explain how Gamma rays interact with matter.

SECTION – B

Answer **any four** questions (**1** mark for Part **a**, **3** marks for Part **b**, **5** marks for Part **c**).
(4×9=36)

3. a) What is the wavelength of an X-ray of energy 100 kev ?
   b) What is absorbed dose ?
   c) Explain about different personal monitoring instruments in radiation science field.

4. a) What is pair production ?
   b) List various artificial ionizing radiation sources.
   c) Differentiate between Bremsstrahlung and Characteristic X-rays.

P.T.O.

5. a) Write down the Bethe formula for specific energy loss.
   b) What is primary and secondary radiations in an X-ray room ?
   c) How the radiation level at different locations in the vicinity of radiation installation is assessed ? Explain.

6. a) What is ALARA in Radiation Science ?
   b) Write a note on radioactive waste disposal from nuclear medicine department.
   c) What are deterministic and stochastic effects of radiation ?

7. a) Define Curie and Becquerel.
   b) What is KERMA ?
   c) Explain the concept of Relative Biological Effectiveness.

8. a) Give the expression for Compton shift in wavelength.
   b) If a radiographer stands 1 meter away from an X-ray tube and is subject to an exposure rate dose of 2mGy per hour, what will it be if the same radiographer moves to a position located 4 meter from the X-ray tube ?
   c) Explain effective radiation protection for personal exposure reduction.

K23P 1424

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (CBSS – Reg./Supple./Imp.)
Examination, October 2023
(2020 Admission Onwards)
PHYSICS
PHY 3C12 – Nuclear and Particle Physics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (either **a** or **b**).

1. a) What is nuclear binding energy and how does the semi-empirical mass formula explain it ? Also, how can we find the Z value for the most stable nucleus using this formula ?

OR

b) Derive the expression for the ground state deuteron wave function in a two-body problem, considering the deuteron as a nucleus composed of a proton and a neutron.

2. a) What is the shell model in nuclear physics and how does it account for nuclear magic numbers and the filling of nuclear energy levels ?

OR

b) What is the of beta decay and how does the Fermi theory explain it ?

(2×12=24)

SECTION – B

(**1** mark for Part (**a**), **3** marks for Part (**b**), **5** marks for Part (**c**)). Answer **any four**.

3. a) Explain nuclear radius.

b) Define angular momentum and parity. How are they used to describe nuclear states ?

c) A nucleus with A = 235, splits into two nuclei whose mass numbers are in the ratio 2 : 1. Find the radii of the new nuclei.

P.T.O.

4. a) What are the characteristic features of the nuclear force ?
   b) Explain the concept of compound nucleus reactions.
   c) A thin sheet of Co^{59}, 0.04 cm thick is irradiated with a neutron beam of flux density 10^{12} neutrons/cm^2/sec for a period of 3 hours. If the cross-section for neutron capture by Co^{59} is 30 barns, calculate the number of nuclei of isotope of Co^{60} produced at the end of the radiation period per cm^2 and the initial beta activity of the sample. Given half life of Co^{60} is 5.2 years and density of Co^{59} is 8.9 g/cm^3.

5. a) Write down different types of Quarks.
   b) Describe the quark model.
   c) Say which of the following reactions are possible ?
      i) $\pi^+ + n^0 \rightarrow \lambda^0 + k^+$
      ii) $\pi^+ + n^0 \rightarrow k^0 + k^+$
      iii) $\bar{\nu}_e + p^+ \rightarrow n^0 + \mu^+$
      iv) $\bar{\nu}_e + p^+ \rightarrow n^0 + e^+$
      v) $\pi^+ + n^0 \rightarrow \pi^- + p^+$

6. a) Why nuclear fission happens ?
   b) Explain characteristics of nuclear fission reaction.
   c) The half lives of two radioactive substance A and B are respectively 1 hour and 2 hours. If initially the number of nuclei of both substances are the same, compare their rate of disintegration after two hours.

7. a) What is magnetic dipole moment of nuclei ?
   b) Explain Spin-Orbit Potential regarding shell model.
   c) Predict the parity, quadrupole moment of the ground state of O_8^{17}, S_{16}^{33}.

8. a) What is Isospin and Strangeness quantum number ?
   b) Discuss the conservation laws that govern nuclear reactions.
   c) Determine the quark content of λ^0, k^+, k^0, $\overline{k^0}$, k^-. **(4×9=36)**

K22P 1424

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (CBSS – Reg./Sup./Imp.) Examination, October 2022
(2019 Admission Onwards)
PHYSICS
PHY 3C 12 : Nuclear and Particle Physics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (either **a** or **b**). **(2×12=24)**

1. a) Explain Fermi theory of beta decay.

   OR

   b) Choose a suitable shell model potential and analyse the expected energy levels, magnetic moment and quadrupole moment of nuclei.

2. a) Explain Quark model using the eight fold way symmetry.

   OR

   b) Discuss various types of nuclear reactions and conservation laws.

SECTION – B

Answer **any 4** (**1** mark for part **a, 3** marks for part **b** and **5** marks for part **c**). **(4×9=36)**

3. a) What are mass spectroscopes ?
   b) How do you calculate nuclear mass using mass spectrograph ?
   c) Explain mass doublet method using an example.

4. a) Define and explain neutron separation energy.
   b) What is the significance of mass parabola ?
   c) Derive semi empirical mass formula.

P.T.O.

5. a) What do you understand by quadrupole moment of nuclei ?
   b) Describe characteristics of nuclear force.
   c) Elaborate on shell model potential.

6. a) Define internal conversion coefficient.
   b) What are the characteristics of magnetic dipole radiation ?
   c) Explain magnetic and inertial confinement.

7. a) Define Isospin of nucleus.
   b) Explain compound-nucleus reaction.
   c) Discuss nuclear reaction cross sections.

8. a) Write any two characteristics of fission.
   b) Calculate the activation energy in the case of ^{236}U.
   c) Calculate the activation energy of fission using Liquid Drop Model.

KANNUR UNIVERSITY

K23P 1423

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (C.B.S.S. – Reg./Supple./Imp.)
Examination, October 2023
(2020 Admission Onwards)
PHYSICS
PHY 3C11 : Solid State Physics

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (either **a** or **b**) : **(2×12=24)**

1. a) Develop the wave equation of an electron in a periodic potential.
   b) Derive an expression for intrinsic carrier concentration in semiconductors.
2. a) Illustrate quantum theory of paramagnetism and arrive at Curie law.
   b) What is Meissner effect ? Derive the London equation and explain its significance.

SECTION – B

Answer **any four** (**1** mark for part **a**, **3** marks for part **b**, **5** marks for part **c**) : **(4×9=36)**

3. a) What is first Brillouin zone ?
   b) Derive Bragg's law from the condition for diffraction in reciprocal space $2\vec{k}\cdot\vec{G} = G^2$ (where $\vec{k}$-wavevector of incoming beam, $\vec{G}$-is the reciprocal lattice vector.)
   c) The Bragg angle corresponding to the first order reflection from (1 1 1) planes in a crystal is 30°, when X-rays of wavelength 1.75 $\mathring{A}$ are used. Calculate the interatomic spacing.

P.T.O.

4. a) What is lattice heat capacity ?

   b) Write a note on Einstein's model of lattice heat capacity.

   c) The Debye temperature of carbon (diamond) is 1850 K. Calculate the specific heat per k mol for diamond at 20 K. Also compute the highest lattice frequency involved in the Debye theory.

5. a) State Ohm's law and write the expression for electrical conductivity.

   b) What is a Bloch function ? Discuss its significance.

   c) A uniform silver wire has a resistivity of 1.54×10^{-8} Ωm at room temperature. For an electric field along the wire of 1 volt/cm, compute the mobility and average drift velocity of the electron assuming that there are 5.8×10^{28} conduction electrons/m^3. Also calculate the relaxation time of the electron.

6. a) What is Hall effect ?

   b) Explain Fermi-Dirac distribution function. Plot this function for various temperature including 0 K.

   c) Calculate the Hall coefficient of sodium based on free electron model. Sodium has bcc structure and the side of the cube is 4.28 $\mathring{A}$.

7. a) What is a Type-I superconductor ?

   b) What is superconductivity ? Write a short note on Dc and Ac Josephson effect.

   c) Calculate the frequency of the AC current produced when a DC voltage of 5 μV is applied across the Josephson Junction.

8. a) What is band gap ?

   b) Write a note on the thermal ionization of donors and acceptors.

   c) In an intrinsic semiconductor, the effective mass of the electron is 0.07 m_e and that of hole 0.4 m_e. If the energy gap is 0.7 eV, determine the intrinsic concentration of charge carriers at 300 K.

———————

K23P 1422

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (CBSS – Reg./Supple./Imp.) Examination, October 2023
(2020 Admission Onwards)
PHYSICS
PHY3C10 : Quantum Mechanics – II

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (either **a** or **b**).

1. a) i) Define scattering amplitude and differential scattering cross section. **3**

   ii) Explain the method of partial wave analysis and apply it to the case of quantum mechanical scattering of low energy incident particles due to a spherically symmetric potential. Hence arrive at the asymptotic form of total scattering cross-section and get the optical theorem. **9**

   OR

   b) i) Explain the principle of identical particles and use it to obtain the energy states of helium atom.

   ii) Explain the scattering of identical particles. **(6+6)**

2. a) Establish the correctness of the Dirac equation as the relativistic wave equation of spin half particles, by applying it to explain the spectra of hydrogen atom. **12**

   OR

   b) Explain the major steps in the formulation of Lagrangian field theory. Obtain classical field equation in terms of the Lagrangian density. Obtain the equivalent expression in terms of Lagrangian. **12**

(2×12=24)

P.T.O.

SECTION – B

Answer **any four** questions. **1** mark for Part **a**, **3** marks for Part **b** and **5** marks for Part **c**.

3. a) Write the expression for the Hamiltonian of an electron in an electromagnetic field characterized by the potentials φ and A.

   b) Explain time-dependent perturbation theory. Give an expression for first order contribution to the coefficient $c_n(t)$ in terms of $H'(r, t)$. What will be its form if the system is initially at $t = 0$?

   c) A system in an unperturbed state n is suddenly subjected to a constant perturbation $H'(r)$ which exists during time $0 \rightarrow t$. Find the probability for transition from state n to state k and show that it varies simple harmonically with angular frequency $(E_k - E_n)/2\hbar$ and amplitude $4\,|H'_{kn}|^2/(E_k - E_n)^2$.

4. a) Write the formula for differential scattering cross-section in a weak potential that makes use the first order Born approximation.

   b) Derive the above formula.

   c) Calculate the differential and total scattering cross-sections in the Born approximation in the potential $V(r) = V_0 \dfrac{e^{-r/R}}{r}$ known as Yukawa potential.

5. a) What is meant by exchange degeneracy ?

   b) Describe how symmetric and anti-symmetric wave functions are constructed from an unsymmetrized solution of the Schrodinger equation for a system of indistinguishable particles.

   c) Show that identical particles represented by anti-symmetric wave functions obey Pauli's exclusion principle.

6. a) Write the covariant form of the Dirac equation.

   b) Show that a Dirac particle has spin ½.

   c) Show that in the non-relativistic limit, Dirac equation reduces to Pauli equation for electron.

7. a) What is meant by a gauge theory ?

   b) Distinguish between World-Space and Minkowski-Space formulations. What are the expected advantages of World-Space formulation in quantum field theory ?

   c) For a system of fermions, show that the occupation number n_k must be restricted to 0 and 1.

8. a) Write down the expression for resultant quantum mechanical state after a measurement that yield an eigenvalue a of an observable that is related with the initial state ψ and projection operator Π_a corresponding to a.

   b) Write a short note on Von Neumann's theorem concerning with quantum mechanical description of elementary processes. Explain its drawback.

   c) State Bell's inequality and Bell's theorem. Derive the inequality. **(4×9=36)**

K22P 1422

Reg. No. : .....

Name : .....

III Semester M.Sc. Degree (CBSS – Reg./Sup./Imp.) Examination, October 2022
(2019 Admission Onwards)
PHYSICS
PHY3C10 : Quantum Mechanics – II

Time : 3 Hours Max. Marks : 60

SECTION – A

Answer **both** questions (Either **a** or **b**). **(2×12=24)**

1. a) Using time dependent perturbation theory, derive expression for transition probability under harmonic perturbation and obtain the condition of detailed balancing.

OR

b) Discuss the first order Born approximation in scattering theory. Obtain the condition for the validity of Born approximation. Estimate the differential cross section for a Coulomb potential given by $V(r) = \frac{Z_1 Z_2 e^2}{r}$.

2. a) Modify the free particle Dirac equation so as to obtain the Dirac equation in presence of an external electromagnetic field. Discuss the non-relativistic limit of this equation and show that it gives the correct magnetic moment of the electron.

OR

b) Discuss the fermion quantisation of the Schrödinger field .

SECTION – B

Answer **any four** questions (**1** mark for Part **a, 3** marks for Part **b** and **5** marks for Part **c**). **(4×9=36)**

3. a) Give the Dyson series for the time evolution operator in interaction picture.

b) Discuss the selection rules for the electric dipole transition.

c) Using the expression for transition rate of absorption, show that a free photon can not absorb radiation.

P.T.O.

4. a) Give the basic idea of partial wave analysis of scattering.

   b) Discuss optical theorem.

   c) Show that the quantum differential cross section for the scattering of two bosons at a scattering angle $\theta = \pi/2$ is twice the classical value when calculated in the centre of mass frame.

5. a) Explain what do we mean by saying that two particles are identical.

   b) Show that a system of two identical particles is represented by either a symmetric wave function or by an anti-symmetric wave function and that symmetry is a constant of motion.

   c) Show that in helium atom, the singlet state is always higher in energy than the triplet state.

6. a) Write down the expressions for charge density and current density in Klein-Gordon theory.

   b) Deduce the expressions for positive and negative charge densities and interpret them in terms of particle energies.

   c) Obtain the Hamiltonian form of the Klein-Gordon equation.

7. a) Express the Hamiltonian density of a field in terms of its Lagrangian density.

   b) Obtain the Hamiltonian density of a field whose Lagrangian density is given by

$$\mathcal{L} = \frac{1}{2}\left\{\frac{1}{c^2}\left(\frac{\partial\varphi}{\partial t}\right)^2 - (\nabla\varphi)^2 - m^2\varphi^2\right\}.$$

   c) Obtain the field equation corresponding to the above Lagrangian.

8. a) According to the famous EPR paper, what are the conditions of completeness and physical reality ?

   b) Write a brief note on the EPR paradox.

   c) Derive Bell's inequalities using a system of two spin half particles.
