Exam. Code : 209004
Subject Code : 5409

M.Sc. Physics 4th Semester

PARTICLE PHYSICS

Paper–Phy-551

Time Allowed—3 Hours] [Maximum Marks—100

Note :– Section A is compulsory. Attempt at least **one** question each from Sections B, C, D and E.

SECTION–A

1. (a) Give two common properties shared by quarks and leptons with explanation.

   (b) Give two differences between quarks and leptons with explanation.

   (c) Draw a labelled Feynman diagram at the quark level for the reaction

   $$K^+ = \pi^0 + e^+ + \nu_e$$

   (d) What are the values of the spin, isospin, charge and strangeness quantum numbers of s-quark ?

   (e) What is the relationship between the hypercharge, the strangeness and the baryon number of a particle ? What is the value of the hypercharge for a strange quark ?

(f) Which interaction is responsible for the decay $K^0 = \pi^+ + \pi^-$ and why ?

(g) What are quark contents of the Ξ^- and Ω^- ?

(h) A positive kaon at rest decays into a muon, μ^+ and neutrino ν_μ, according to

$$K^+ = \mu^+ + \nu_\mu$$

What is the energy of muon ? Masses of kaon and muon are 494 and 106 MeV/c^2, respectively; the neutrino is effectively massless.

(i) What is the effect of charge conjugation operator ? How do angular momentum and linear momentum change under that operation ?

(j) Explain how symmetry constraints allow only one of the two reactions

$$\rho^0 = \pi^+ + \pi^-$$

$$\rho^0 = \pi^0 + \pi^0$$

The ρ^0 is a spin 1 meson while the pion has spin 0.

2×10=20

SECTION–B

2. Determine experimentally the spin and parity of all the charged as well as neutral pions. 20

3. Consider the reactions :

(a) $\pi^+ + p \rightarrow \Delta^{++} \rightarrow \pi^+ + p$

(b) $\pi^- + p \rightarrow \Delta^0 \rightarrow \pi^- + p$

(c) $\pi^- + p \rightarrow \Delta^0 \rightarrow \pi^0 + n$

These reactions, which conserve isospin can occur with $I = \frac{3}{2}\hbar$ or $I = \frac{1}{2}\hbar$. Calculate the ratio of their cross-section i.e. $\Gamma_a : \Gamma_b : \Gamma_c$. 20

SECTION–C

4. Indicate, with an explanation, whether the following interactions proceed through the strong, electromagnetic or weak interactions, or whether they do not occur at all.

(a) $\pi^0 \rightarrow \gamma + \gamma$

(b) $\tau^+ \rightarrow \mu^+ + \nu_\mu$

(c) $\Xi^- \rightarrow \pi^- + \Lambda$

(d) $\Delta^{++} \rightarrow p + \pi^+$

(e) $\Omega^- \rightarrow K^- + n$

(f) $n + K^+ \rightarrow \pi^+ + \Lambda$

(g) $n + K^- \rightarrow \pi^- + \Lambda$

(h) $\mu^+ + \mu^- \rightarrow \bar{\nu}_\tau + \nu_\tau$ 20

5. (a) The combination of quarks which can form a baryon are dictated by symmetry constraints. Explain these constraints in terms of the spin, flavour (or isopin) and colour wevefunction of the quarks. 12

(b) Baryons composed of two light (u or d) quarks and one s-quark form, spin ½ baryons (Σ^+, Σ^0, Σ^-, Λ) and spin 3/2 baryons state. With justification, what the flavour and spin wavefunctions are for the light quarks in the spin ½ baryons ? Explain clearly why there is no spin 3/2 singlet (equivalent to the Λ). 8

SECTION–D

6. (a) Quark flavour is conserved in the strong interaction, while the weak interaction allows the decay of heavy quarks into lighter ones. Explain how such decays are permitted according to Cabibbo theory. What is the significance of the magnitude of different elements of the matrix for these decays ? 10

(b) Can the charm quark decays into a (b, s, u or d) quark ? For each case state with an explanation whether the decay is forbidden, allowed but unlikely or likely to occur. Draw a fully-labelled Feynman diagram of the most probable decay mode. 10

7. With the help of Dirac spinors, establish the vector, axial-vector interactions prevailing in weak decay. 20

SECTION–E

8. Establish the Euler-Lagrange equation for the fields and hence construct the Proca-Lagrangian for an electromagnetic field. 20

9. Firstly state with explicit notations and diagrams the Feynman rules and hence write down the Matrix element for Bhabha scattering. 20

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M.Sc. Physics 4th Semester

CONDENSED MATTER PHYSICS—II

Paper—Phy-552

Time Allowed—3 Hours] [Maximum Marks—100

Note :— Attempt all the questions from Section-A and attempt **ONE** question from each of the Sections B, C, D and E.

SECTION—A

1. (i) Define magnetic susceptibility and give its physical significance.

   (ii) Define Larmor theorem.

   (iii) Neither Mn nor Cr are ferromagnetic by themselves, yet some of their alloys with other elements are ferromagnetic. Why ?

   (iv) Can the domain structure in a ferromagnetic substance be detected by X-ray diffraction ? Give appropriate evidence of your answer.

   (v) What are the consequences of magnetostriction effect in ferromagnetic materials ?

(vi) Give one example of superconductivity for designing of technical device.

(vii) What is coherence length and how it determines the superconducting behaviour of a given material ?

(viii) Discuss the formation of Cooper pair.

(ix) Compare optical properties of metals and non-metals.

(x) Compare the exciton absorption with free carrier absorption. 2×10=20

SECTION—B

2. (i) Describe quantum theory of paramagnetism. 12

(ii) How the quenching of orbital angular momentum takes place ? 8

3. (i) Describe the Gouy's method to measure magnetic susceptibity. 10

(ii) Describe the paramagnetic susceptibility of conduction electrons. 10

SECTION—C

4. (i) Discuss the formation of ferromagnetic domain. 10

(ii) Describe the neutron magnetic scattering. 10

5. (i) Find the thickness and energy of Bloch wall. 10

(ii) Describe the origin of anisotropy energy. 10

SECTION—D

6. Describe the structure and properties of high temperature superconducting materials. 20

7. (i) Explain the thermodynamics of superconductors in comparison to normal conductors. 15

(ii) What is the significance of BCS ground states ? 5

SECTION—E

8. (i) Write a short note on following :—

(a) Sulphide phosphor

(b) Thallium activated alkali halides. 10

(ii) Describe the application of interaction of light with solids. 10

9. (i) Distinguish between direct and indirect band gap. 10

(ii) Describe absorption process involved in materials containing impurities. 10

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Subject Code : 5412

M.Sc. Physics 4th Semester

RADIATION PHYSICS

Paper—Phy-562

Time Allowed—3 Hours] [Maximum Marks—100

Note :— Section A is compulsory. Attempt **ONE** question from each of the Sections B, C, D and E. All questions carry equal marks.

SECTION—A

1. (a) What do you mean by dose equivalent ?

   (b) Define the term kerma.

   (c) What is quality factor ?

   (d) List the names of different dosimeters.

   (e) Which are the general applications of dosimeters ?

   (f) What is Relative Biological Effectiveness (RBE) ?

   (g) Which are the acute biological effects of radiations ?

   (h) Name some radiation shielding materials.

   (i) What is point source ?

   (j) What is buildup factor ?

SECTION—B

2. Discuss various sources of ionizing radiations.

3. State and discuss Bragg-Gray principle.

SECTION—C

4. What do you mean by dosimeter ? Discuss solid state dosimeter (TLD).

5. Compare chemical detector with neutron detectors.

SECTION—D

6. Discuss stochastic and non-stochastic biological effects of radiations.

7. Name the sources of radiation waste and discuss the disposal of radiation waste.

SECTION—E

8. Discuss thermal and biological shields.

9. What do you mean by radiation attenuation ? Discuss radiation attenuation from a plane source.

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Subject Code : 5413

M.Sc. Physics 4th Semester

REACTOR PHYSICS

Paper—Phy—563

Time Allowed—3 Hours] [Maximum Marks—100

Note :- Section A is compulsory. Attempt one question from each of the Sections B, C, D and E. All questions carry equal marks.

SECTION—A

1. (a) What is point source ?

   (b) What is transport mean free path ?

   (c) What is the difference between diffusion and drift ?

   (d) What is slowing down density ?

   (e) What do you mean by critical size of a nuclear reactor ?

   (f) List some applications of nuclear reactor.

   (g) What is the role of moderator in nuclear reactor ?

   (h) Name different fuels obtained from breeder reactor.

   (i) Define breeding ratio.

   (j) Name any five reactors in India.

SECTION—B

2. What do you mean by neutron diffusion ? In thermal diffusion obtain steady state equation.

3. Find the solution of diffusion equation for an infinite plane source in a finite medium.

SECTION—C

4. Discuss the energy distribution of thermal neutrons.

5. What is the difference between thermal and fast neutrons ? Derive Fermi age equation.

SECTION—D

6. Discuss neutron cycle and then derive four factor formula.

7. What do you mean by buckling ? Discuss geometrical buckling taking the case of any type of geometry.

SECTION—E

8. Discuss fast breeder reactors in detail.

9. Name the conditions affecting the reactivity of a nuclear reactor and then discuss the effect of temperature.