Open Book Examination, September/October 2020

Third Semester M.Sc. Physics

Course: MP 3.1- Quantum Mechanics-2

Time: 3 Hours Max. Marks: 80

***Instructions**: Answer all questions.*

1. (a) What is perturbation? Explain with an example. (3)

(b) Discuss time independent perturbation theory and obtain the expressions for first and second order correction terms for energy. (12)

OR

2. (a) Describe one dimensional WKB approximation in solving Schrödinger's equation. (6)

(b) A one-dimensional harmonic oscillator in its ground state for $t \leq 0$ is subjected to a spatially uniform, time dependent force given by $F(t) = F_o e^{-\mu t}$ for $t \geq 0$. Calculate the probability amplitude for finding the oscillator in its first excited state. (5)

(c) Write a note on Fermi golden rule. (4)

3.(a) Distinguish between differential scattering cross section and total scattering cross section. (5)

(b) Obtain the integral equation of scattering using Born approximation. (10)

OR

4. (a) Obtain the expression for scattering cross section using Born approximation for Yukawa potential. (6)

(b) Obtain Faxen and Holtzmark formula for scattering amplitude due to spherically symmetric central potential between two interacting particles. (9)

5. (a) Distinguish between laboratory and center of momentum frames of references. Obtain the relation between the scattering cross section in lab and center of momentum frames. (10)

(b) Obtain Lorentz covariant form of Schrödinger equation. (5)

OR

6.(a) Obtain relativistic continuity equation of wave functions. (5)

(b) Explain the difficulties involved with the Klein-Gordon equation. (5)

(c) Obtain the covariant form of Dirac equation. (5)

7. (a) Obtain Euler-Lagrange equations of a classical field. (10)

(b) What are creation and annihilation operators? Discuss their properties. (5)

OR

8. (a) Write a note on Fock states. (4)

(b) Describe how the fermion field is quantized and obtain the corresponding Hamiltonian. (6)

(c) Describe Coulomb scattering of two finite mass particles using Feynman diagram and obtain Rutherford's scattering formula. (5)

9. Answer any **four** of the following (4X5=20)

(a) Obtain an expression for first order time dependent perturbation probability.

(b) Obtain Schrödinger-like and Heisenberg-like equations in presence of time dependent potentials.

(c) Obtain an expression for scattering current density and differential scattering cross section when a central field scatters a plane wave.

(d) Discuss Rutherford scattering formula using Born approximation.

(e) Show that the Dirac matrices are even dimensional.

(f) Write a note on Dirac's theory of hole.

(g) Obtain an expression for electric and magnetic fields in terms of creation and annihilation operators.

(h) Write a note on Feynman diagrams.

Open Book Examination, September/October 2020

Third Semester M.Sc. Physics

Course: MP 3.2- Nuclear Physics

Time: 3 Hours Max. Marks: 80

***Instructions**: Answer **all** questions.*

1. (a) Describe the method of mirror nuclei to measure the nuclear radii. (10)

   (b) Obtain an expression for the threshold energy of a nuclear reaction. (5)

OR

2. (a) Describe an experiment employed for the determination of nuclear magnetic moment. (10)

   (b) Distinguish between pickup and stripping nuclear reactions. (5)

3 .(a) Discuss the different methods of Interaction of gamma and x-rays with matter. (10)

   (b) Explain how semi-empirical binding energy formula is applied for assessing the stability of nuclei. (5)

OR

4. (a) What are magic numbers? Discuss briefly the role of spin-orbit coupling in obtaining all the magic numbers in shell model. (10)

   (b) Describe with necessary theory, the slowing down of neutrons. Explain logarithmic decrement in energy. (5)

5. (a) Discuss the Fermi's theory of beta decay. (10)

   (b) Discuss different methods of excitation of nuclei. (5)

OR

6 .(a) Discuss the Gamow's theory Alpha decay. (10)

   (b) What is meant by a critical reactor? On which factors does the critical size of the reactor depend? (5)

7. (a) Discuss Yukawa's theory of nuclear forces. (10)

   (b) What are the important conservation laws operating in the various interactions between elementary particles? (5)

OR

8. (a) Discuss the eight-fold way symmetry of baryons. (10)

(b) Narrate the elementary ideas of the standard model. (5)

9. Answer **any four** of the following (4X5=20)

(a) How much of energy is released by the fission of 1.5 kg of ^{235}U by the thermal neutrons?

(b) Calculate the threshold energy required to initiate the reaction $^{31}P(n,P)^{31}Si$.

Given that: M_p = 1.00814 amu, M_n = 1.00898 amu, mass of ^{31}P = 30.98356 amu and mass of ^{31}Si = 30.98515 amu.

(c) In an absorption experiment with 1.14 MeV gamma radiations from ^{65}Zn, it is found that 25 cm of aluminium reduces the beam intensity to 2%. Calculate the half thickness and the mass attenuation coefficient of aluminium [Given: the density of aluminium is 2700 kg/m^3]

(d) Calculate the average logarithmic energy decrement per collision and the number of collisions required to reduce the energy of neutrons from 5MeV to 0.5MeV in carbon. [Given $\zeta = 0.16$ for carbon].

(e) $^{212}Bi_{83}$ decays with a half-life of 60.5 minutes by emitting 5 groups of α-particles with energies- 6.08 MeV, 6.04 MeV, 5.76 MeV, 5.62 MeV and 5.60 MeV. Calculate the α-disintegration energies. Write down the nuclear reaction.

(f) What would be the length of the side of a cubical reactor having geometrical buckling of 64? If the reactor is spherical, calculate the critical radius of the same.

(g) Give the quark combination of p, n and π^+. Show that charge and spin quantum numbers are satisfactorily accounted for.

(h) Explain the role of gluons in the interaction between quarks.

Open Book Examination, September/October 2020

Third Semester M.Sc. Physics

Course: MP 3.3-Condensed Matter Physics

Time: 3 Hours Max. Marks: 80

***Instructions**: Answer **all** questions.*

1 (a) What are Miller indices? Obtain Miller indices for a plane with intercept (a/p, b/q, c/r) along the crystallographic axis. (9)

(b) List the seven crystal systems and explain. (6)

OR

2. (a) Describe the Laue method of X-ray diffraction and mention its limitations. (10)

(b) How is the reciprocal lattice vector G_{hkl} related to the Miller plane (*hkl*)? (5)

3 .(a) Explain the principles of neutron diffraction technique. (5)

(b) Define magnetic susceptibility and derive an expression for magnetic susceptibility of a diamagnetic material using Langevin theory. (10)

OR

4. (a) Explain the spontaneous magnetization of ferromagnetic materials. (5)

(b) Give the Néel's theory of anti-ferromagnetism based on two sublattice model. (10)

5. (a) Explain briefly the BCS theory of superconductors. (5)

(b) Setup London equations and deduce an expression for the penetration depth. (10)

OR

6 .(a) Discuss the entropy of a superconducting material. (10)

(b) Mention the applications of superconductors. (5)

7. (a) Derive an expression for the carrier concentration in an intrinsic semiconductor. (9)

(b) Obtain an expression for Fermi energy in an intrinsic semiconductor. (6)

OR

8. (a) Deduce an expression for the ionization energy of donors in an extrinsic semiconductor. (9)

(b) Obtain an expression for Fermi energy of p-type semiconductor. (6)

9. Answer any **four** of the following (4X5=20)

(a) Obtain Miller indices for (100), (010) and (111) planes.

(b) Given that for a unit cell a = 10 Å, b = 5 Å, c = 8 Å, $\alpha = \beta = \gamma = 90^0$, find its reciprocal lattice.

(c) Assuming that the iron in the metallic form has a magnetic moment $\mu_J = 2\ \mu_B$ per atom. Calculate the Curie constant and the Weiss constant. Given: N 8.49 X 10^{28} m^{-3}, $\mu_B = 9.27$ X 10^{-24} JT^{-1} and $T_c = 1043$ K.

(d) For a solid, the mean square distance of an electron from the nucleus is $\left\langle r^2 \right\rangle = 10^{-20} m^2$ and the number of atoms is N = 10^{28} m^3 with each atom containing Z = 2 electrons. Find the diamagnetic susceptibility. Given m_e = 9.11 X 10^{-31} kg and e = 1.602 X 10^{-19}C.

(e) Estimate the magnetic field strength necessary to destroy superconductivity in a sample of lead at 4.3 K. Given: T_c = 7.2 K and $H_c(0)$ = 0.090 T.

(f) On the basis of BCS theory calculate the energy gap in eV of lead at 0 K and 6.9 K. Given T_c = 7.2 K and k_B = 1.38 X 10^{-23} JK^{-1}.

(g) For an intrinsic semiconductor with gap width of E_g = 0.76 eV, calculate the carrier concentration at 300 K. Given: $m_p^* = 3.644 \times 10^{-31}$ kg , $m_n^* = 5.1 \times 10^{-31}$ kg and k_B = 1.38 X 10^{-23} JK^{-1}.

(h) Calculate the ionization energy of a donor atom in a semiconductor with $m_n^* = 0.25 m_0$ and $\varepsilon = 16.$ Ionization energy of hydrogen atom is 13.6 eV.

Open Book Examination, September/October 2020

Third Semester M.Sc. Physics

Course: MP 3.4- Accelerator Physics

Time: 3 Hours Max. Marks: 80

***Instructions**: Answer **all** questions.*

1.	(a)	Explain briefly semi classical treatment of ion sources.	(10)
	(b)	Write a note on conductivity and stability of plasma.	(5)
		OR	
2.	(a)	Explain Paschen's law for gas breakdown.	(6)
	(b)	Explain focusing properties of linear fields.	(9)
3 .	(a)	Explain the principle and working of Cockcroft-Walton generator.	(10)
	(b)	Describe how negative ions can be accelerated in Tandem accelerator.	(5)
		OR	
4 .	(a)	Explain the principle, construction and working of cyclotron with a neat labeled diagram.	(10)
	(b)	Write a note on beam focusing.	(5)
5.	(a)	With a neat schematic diagram of proton synchrotron, explain its principle, construction and working.	(10)
	(b)	With necessary theory obtain the resonance condition for Microtron.	(5)
		OR	
6 .	(a)	Explain alternating gradient principle. Using vertical and horizontal plane focusing obtain the expression for field index.	(10)
	(b)	Write a note on the Indus - 2 synchrotron accelerator.	(5)
7.	(a)	Describe the kinematics of Rutherford backscattering.	(10)
	(b)	Explain mathematical basis of the quantitative estimate of two light elements constituting a sample.	(5)
		OR	
8.	(a)	Explain the general types of radiation effects on materials.	(10)
	(b)	Explain radionuclide therapy.	(5)

9. Answer **any four** of the following (4X5=20)

(a) Write a note on semi-classical treatment of ionization**.**

(b) Calculate the spark voltage for dry air at the pressure gap product 4.0 if the minimum spark constants are 327 V and 0.567 torr cm respectively.

(c) Write a note on the development of accelerators.

(d) If the maximum electric field that can be tolerated perpendicular to the surface of its belt is 2 MV/m. Find the maximum charging current in a Van de Graaff generator. The width of the belt is 0.5 m and its speed is 25 m/s.

(e) Mention applications and limitations of Betatron.

(f) What is alternating gradient principle?

(g) Describe the consequences of mutation.

(h) Explain the applications of radioisotopes in medical field.