St. Philomena's College (Autonomous), Mysore

Question Bank

Programme: M. Sc. Physics
III Semester

Course Title: NUCLEAR AND PARTICLE PHYSICS
Course Type: Hard Core
Q.P Code: 58202

No.	Module	Question	Marks
1	1	Define nuclear spin (I) and parity (π).	3
2	1	Write a short note on electric quadrupole moment of the nucleus.	3
3	1	Is it possible to estimate size of the nucleus by scattering of visible light?.	3
4	1	In electron scattering experiments, how do you identify electrons scattered from electrons and from nuclei?.	3
5	1	Define Bohr magneton and deduce its magnitude.	3
6	1	Why infinite depth potential in shell model is not realistic?.	3
7	1	Explain nuclear isomerism with example.	4
8	1	Give the basic assumptions of nuclear shell model.	4
9	1	Explain how the ground state spin and parity for a nucleus in ground state is determined using the shell model.	4
10	1	Find the most stable isobar of A=25 using Semi empirical mass formula.	4
11	1	Prove that nuclear density is independent of its mass.	4
12	1	Discuss the role of electric quadrupole moment in predicting the effective shape of the nucleus.	6
13	1	Outline the quantum mechanical formalism to determine nuclear charge distribution.	6
14	1	With necessary explanation compare the proton distribution in ^{16}O, ^{116}Sn and ^{197}Au.	6
15	1	Obtain the mass distribution from charge distribution and with necessary explanation compare the mass distribution in ^{16}O, ^{116}Sn and ^{197}Au.	6
16	1	If binding energy $BE = 2.225\ MeV$ and range of interaction $r_0 = 2.1\ fm$ for deuteron. Assume square well potential and with necessary justification, arrive at the final form of time independent Schrodinger equation.	6
17	1	Assume square well potential for deuteron and solve the time independent Schrodinger equation and obtain the solution in the region $r < r_0$ and $r > r_0$.	6
18	1	Apply continuity condition on the solution in the region $r < r_0$ and $r > r_0$ at $r = r_0$. Duduce that depth of square well pottential for deuteron is $V_0 = 36\ MeV$.	6
19	1	How magnetic moment arises and how it is related to orbital angular momentum?.	6
20	1	Define magnetic moment due to orbital and spin motion of nucleons. Deduce the magnitude of nuclear magneton.	6
21	1	Explain why single particle pottential is different for proton and neutron?, comment on the diffrences using Woods-Saxon pottential.	6
22	1	Define Nuclear spin and pairing of nucleons. Why the nuclear spin of even-even nuclei is zero?.	6
23	1	Explain the molecular beam experiment to determine nuclear magnetic moment.	8
24	1	Explain how the mesic X-ray method is used to estimate the nuclear radius parameter.	8
25	1	Obtain the general expression for the Q value of the nuclear reactionX(x,y)Y.	8
26	1	Analyze the role of spin orbit interaction in obtaining all the magic numbers using the shell model.	8
27	1	With necessary details explain the fermi gas model of the nucleus.	8
28	1	What is the evidence of shell structure in nuclei? Explain the main assumptions of the nuclear shell model.	8
29	1	What are mirror nuclei? Explain how the Coulomb energy difference between mirror.	9
30	1	nuclei can be used to determine the nuclear radius parameter.	9

No.	Module	Question	Marks
31	1	Discuss the electron scattering experiment to measure the nuclear charge radius.	9
32	1	Illustrate the molecular beam experiment to determine nuclear magnetic moment.	9
33	1	Discuss the nuclear charge and mass distribution and show that nuclear mass distribution can be depicted by Woods-Saxon function.	9
34	1	If $\rho = 0.9\rho_0$ and $\rho = 0.1\rho_0$ in Woods-Saxon function, obtain the value of R+a and R-a, where R is the mean radius of the nuclei.	9
35	1	Obtain the expression for binding energy (BE) in terms of atomic mass and calculate BE of helium nuclei using following data: $M^{at}({}^4_2He) = 4.0026u$, $M^{at}({}^1_1H) = 1.0078u$ and $M_n = 1.0086u$.	9
36	1	Explain the correction factors of semi empirical formula for binding energy of Nuclei.	9
37	1	Justify that high energy electrons can be used to determine size of the nucleus. Estimate the order of electron's kinetic energy required.	9
38	1	In the electron scattering experiment from carbon target, minimum number of electrons scatter at $\theta = 51°$, show that size of nuclei can be estimated using optical analogy. If kinetic energy of electrons is 420 MeV, estimate the size of carbon nuclei.	9
39	1	Show that single particle shell model with infinite square well pottential fail to explain all observed magic numbers.	9
40	1	Show that single particle shell model with 3 dimensional harmonic oscillator pottential fail to explain all observed magic numbers.	9
41	1	In single particle shell model with 3 dimensional harmonic oscillator pottential, discuss the effect of spin interactions on the energy levels.	9
42	1	Write the energy level diagram and show that observed magic numbers can be explained by shell model with spin interactions.	9
43	1	Compare the energy levels in shell model with 3 dimensional harmonic oscillator pottential and Woods-Saxon pottential.	9
44	1	What is the parity of even-even nuclei?. Illustrate with a example.	9
45	1	Obtain I^π for ${}^{61}_{28}Ni_{33}$ using shell model. If $I^\pi = \frac{3}{2}^-$ is observed for ${}^{61}_{28}Ni_{33}$, how do you justify the difference?.	9
46	1	Using shell model obtain I^π for ${}^{61}_{28}Ni_{33}$ and compare it with the observed value $I^\pi = \frac{3}{2}^-$. Show that the difference can be accounted by braking the pairs.	9
47	1	If $I^\pi = \frac{5}{2}^+, \frac{1}{2}^+, \frac{1}{2}^-$ for ground state, first and second exited states, respectively. Show that how the observed values can be accounted in shell model.	9
48	1	Obtain an expression for the magnetic dipole moment of odd A nuclei on the basis of single particle model.	10
49	1	Prove that only lower magic numbers can be generated at shell closure using shell model theory with infinite square well potential.	10
50	1	Explain the stability of isobars on the basis of liquid drop model.	10
51	1	Discuss the basic assumption of liquid drop model of nucleus. Explain how this model is used to estimate semi empirical mass formula.	10
52	2	Define range and stopping power.	3
53	2	Discuss the role of moderators in nuclear reactors.	3
54	2	What are reflectors? Give their significance.	3
55	2	What are breeder reactors? Explain with examples.	4
56	2	Explain internal and external Bremhstralung radiations.	4
57	2	Calculate the energy released during the symmetric fission of ${}^{236}U$.	4
58	2	Explain photodisintegration process.	4
59	2	Discuss the Mössbauer effect. List the necessary conditions for Mössbauer effect to occur.	6
60	2	Discuss the Coulomb correction to the momentum distribution of beta particles in allowed beta decay.	6

No.	Module	Question	Marks
61	2	Explain the classification of beta decay based on Comparative half life values.	6
62	2	Discuss the conditions for controlled chain reaction and define the multiplication factor.	6
63	2	Write a note on Bremsstrahlung radiation.	6
64	2	Describe the important features of beta ray spectrum emitted by radioactive nuclides.	8
65	2	Explain how neutrino hypothesis explains the the process of beta decay.	8
66	2	Explain the role of neutrino hypothesis in understanding the beta ray spectrum. What is Kurie plot.	8
67	2	Define linear and mass attenuation coefficients and obtain an expression for the same.	8
68	2	Analyze the role of reflectors and moderators in a nuclear reactor.	8
69	2	Derive an expression for the threshold energy of the endoergic nuclear reaction of the form X(x,y)Y.	10
70	2	Explain the internal conversion process and Auger effect. Obtain an expression for the conversion coefficient.	10
71	2	Obtain an expression for the critical volume of a homogeneous spherical reactor using the neutron diffusion equation.	10
72	2	Describe how a NaI(Tl) Scintillation detector is used for gamma ray spectroscopy.	10
73	2	Outline the Fermi's theory to explain the continuous energy spectrum in beta decay.	12
74	2	Obtain the classical formula for energy loss of heavy charged particle through matter,and then introduce relativistic corrections to obtain Bethe- Bloch formula.	12
75	3	Define Isospin and give its importance.	3
76	3	Write a note on pair production, with reference to interaction of gamma rays with matter.	3
77	3	Write a short note on quarks.	3
78	3	Explain the need for strangeness quantum number.	3
79	3	Discuss the classification of bosons.	3
80	3	Explain Gellmann-Nishijima scheme.	4
81	3	What is $\tau - \theta$ puzzle? Explain how it was resolved.	4
82	3	Write the possible spin combinations in Deuteron.	5
83	3	Write the possible combinations of orbital and spin angular momentums of nucleons in Deuteron.	5
84	3	Derive the effect of spin interactions on the potential in Deuteron.	5
85	3	Explain the properties of π mesons.	6
86	3	Explain the CP Violation in Kaon decay.	6
87	3	If binding energy $BE = 2.225\ MeV$ and range of interaction $r_0 = 2.1\ fm$ for deuteron. Assume square well potential and with necessary justification, arrive at the final form of time independent Schrodinger equation.	6
88	3	Assume square well potential for deuteron and solve the time independent Schrodinger equation and obtain the solution in the region $r < r_0$ and $r > r_0$.	6
89	3	Apply continuity condition on the solution in the region $r < r_0$ and $r > r_0$ at $r = r_0$. Duduce that depth of square well pottential for deuteron is $V_0 = 36\ MeV$.	6
90	3	Discuss operational definition of differential and total cross-section.	6

No.	Module	Question	Marks
91	3	In n-p scattering, if incoming plane wave function (e^{ikz}) is expressed in terms of partial waves given by $e^{ikz} = \sum_{l=0}^{\infty} i^l (2l+1) j_l(kr) p_l(\cos\theta)$, obtain the expression for differential cross-section ($\sigma(\theta)$) as a function phase shift (δ_l). Where $j_l(kr) = \frac{\sin(kr - \frac{l\pi}{2})}{kr}$ in the limit $r \to 0$.	6
92	3	In low energy n-p scattering, If $E = 1\ MeV$ and range of interaction is $r_0 = 2\ fm$, show that angular momentum is zero.	6
93	3	In n-p scattering, if $e^{ikz} = \sum_{l=0}^{\infty} i^l (2l+1) j_l(kr) p_l(\cos\theta)$, where plane wave function is expanded as a function of angular momentum l.Show that differential cross-section ($\sigma(\theta)$) is a function phase shift (δ_l). Where $j_l(kr) = \frac{\sin(kr - \frac{l\pi}{2})}{kr}$ in the limit $r \to 0$.	6
94	3	Calculate angular momentum of $E = 2\ MeV$ neutron, by assuming neutron-proton interaction range $r_0 = 2\ fm$.	6
95	3	Show that $\sigma_{total} = \frac{4\pi}{k^2} \sin^2(\delta_0)$, for low energy n-p scattering.	6
96	3	With supporting experimental evidence, explain the exchange character of nuclear force.	8
97	3	Explain the spin dependence and charge symmetric properties of nuclear of nuclear force.	8
98	3	Discuss the general features of nuclear forces based on the experimental evidences.	9
99	3	Explain the spin dependence and tensor character of nuclear of nuclear force.	9
100	3	Discuss in detail the classification of particles based on their spin.	9
101	3	Outline the elementary ideas of standard model.	9
102	3	What are strange particles? Explain the strangeness quantum number with examples.	9
103	3	What are nuclear forces? With necessary details explain the spin dependence and charge independence character of nuclear forces.	10
104	3	Explain the classification of fundamental forces. Give their salient features comparing and contrasting their basic properties.	10
105	3	Explain the octet symmetry of baryons and mesons using weight diagram.	10
106	3	Discuss the Yukawa's theory of nuclear force.	12
107	3	Discuss the conservation laws of elementary particles with examples.	12

For 3 and 4 credit Courses

<table>
<tr><td colspan="4">St. Philomena's College(Autonomous), Mysuru</td></tr>
<tr><td colspan="4">I/II/III/IV Semester M.Sc. Examination Month – Year</td></tr>
<tr><td colspan="4">Subject:</td></tr>
<tr><td colspan="4">Title:</td></tr>
<tr><td colspan="2">Time: 3 hours</td><td></td><td>Max. Marks:70</td></tr>
<tr><td colspan="4">Instruction: Answer any one full question from Section – A, Section-B and Section-C and any four questions from Section – D.</td></tr>
<tr><td colspan="4">Section - A</td></tr>
<tr><td>1.</td><td>a.</td><td>Question to be asked from unit I</td><td rowspan="2">18</td></tr>
<tr><td></td><td>b.</td><td>Question to be asked from unit I</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>2.</td><td>a.</td><td>Question to be asked from unit I</td><td rowspan="2">18</td></tr>
<tr><td></td><td>b.</td><td>Question to be asked from unit I</td></tr>
<tr><td colspan="4">Section - B</td></tr>
<tr><td>3.</td><td>a.</td><td>Question to be asked from unit II</td><td rowspan="2">18</td></tr>
<tr><td></td><td>b.</td><td>Question to be asked from unit II</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>4.</td><td>a.</td><td>Question to be asked from unit II</td><td rowspan="2">18</td></tr>
<tr><td></td><td>b.</td><td>Question to be asked from unit II</td></tr>
<tr><td colspan="4">Section - C</td></tr>
<tr><td>5.</td><td>a.</td><td>Question to be asked from unit III</td><td rowspan="2">18</td></tr>
<tr><td></td><td>b.</td><td>Question to be asked from unit III</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>6.</td><td>a.</td><td>Question to be asked from unit III</td><td rowspan="2">18</td></tr>
<tr><td></td><td>b.</td><td>Question to be asked from unit III</td></tr>
<tr><td colspan="4">Section - D</td></tr>
<tr><td>7.</td><td colspan="2">Question to be asked from unit I</td><td>04</td></tr>
<tr><td>8.</td><td colspan="2">Question to be asked from unit I</td><td>04</td></tr>
<tr><td>9.</td><td colspan="2">Question to be asked from unit II</td><td>04</td></tr>
<tr><td>10.</td><td colspan="2">Question to be asked from unit II</td><td>04</td></tr>
<tr><td>11.</td><td colspan="2">Question to be asked from unit III</td><td>04</td></tr>
<tr><td>12.</td><td colspan="2">Question to be asked from unit III</td><td>04</td></tr>
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Note : Marks of Section A, B and C can be any combinations of 18. For example (12+6), (10+8),(9+9),(10+4+4),(8+6+4) etc,.