Sample Questions on NUCLEAR PHYSICS

1. Explain proton-electron model of the nucleus? Why was it discarded?
2. What is proton-neutron model for the nucleus? What are the main achievements of this model?
3. Define *nuclear mass*? Is *nuclear mass* equal to the masses of the nucleons present in the nucleus?
4. What the charge on the nucleus?
5. How can you estimate the size of the nucleus?
6. Write down empirical expression for the nuclear radius? What is the *nuclear parameter*?
7. Define the following with suitable examples: (a) isotopes, (b) Isotones (c) Isobars (d) Isomers (e) Mirror nuclei.
8. Define *atomic mass unit*. Express it in terms of MeV.
9. What is *mass defect*?
10. Define *binding energy* of the nucleus. What does it physically mean?
11. How is binding energy related to the stability of the nucleus?
12. Define *packing fraction*. How is it related to the binding energy of the nucleus?
13. Draw the packing fraction vs. mass number plot and interpret the results.
14. Draw the binding energy per nucleon versus mass number (A) plot. What are the main interesting conclusions those can be drawn from this plot?
15. If the mass of a nucleon be 1.67×10^{-27}kg, calculate the value of the nuclear density.
16. Find the radius of (a) ${}^{12}_{6}C$ (b) ${}^{208}_{82}Pb$ nucleus.
17. If the nuclear radius of ${}^{27}_{13}Al$ is 3.6 F, then find the approximate nuclear radius of ${}^{64}_{29}Cu$.
18. Find the stable nucleus having a radius equal to one third that of ${}^{189}Os$.
19. On what factors the stability of a nucleus depend?
20. Explain the following nuclear properties and indicate the various factors on which they depend: (a) spin, (b) magnetic moment, (c) parity.
21. Neutron is an electrically neutral particle; still experiment shows that it is having a negative magnetic moment-why?
22. What is meant by *parity* of the nucleus?
23. Find the ratio of nuclear magnetic moment to Bohr magneton.
24. What is nuclear force? Give some of the important Charcateristics of nuclear force.
25. Give Yukawa theory of nuclear force.
26. Nuclear force has the property of saturation-explain.
27. Nuclear force is charge independent-explain.
28. Explain how the nuclear force is spin dependent.
29. In what respect a nucleus resembles a liquid drop?
30. Explain the similarities between a liquid drop and an atomic nucleus. How were these similarities developed into the liquid drop model for the nucleus?
31. What are the major limitations of the liquid drop model?
32. Establish the semi-empirical mass formula and explain the significance of each term.
33. Write Bethe-Wiezsacker's semi-empirical mass formula?
34. Define radioactivity. State Soddy-Fajan's displacement law.

35. Radioactivity is a random phenomenon-explain.
36. What is exponential growth?
37. State the law of radioactive disintegration. Hence show that a radioactive element decays exponentially with the passage of time.
38. Define *half-life*of a radioactive substance. How is it related to the decay constant?
39. Define *mean-life* or *average life* of a radioactive sample. Show that it is equal to the reciprocal of the decay constant.
40. Define the term *activity* of a radioactive sample. State the units activity of a radioactive sample.
41. Work out the elementary theory of *successive disintegration* of radioelements. Hence obtain the conditions for their secular and transient equilibrium.
42. Define range of α −particles.
43. State the factors on which the range of α −particles depend.
44. State Geiger's law.
45. State Geiger-Nuttal law. What is the importance of the law?
46. Derive an expression for α −disintegration energy.
47. Explain the *fine structure* of α −particles and discrete energy levels.
48. What are *long-range* α −particles?
49. What are the different forms of β −decay?
50. What is continuous β −ray spectrum? What are the major difficulties faced while explaining such spectrum?
51. What is the discrete β −ray spectrum? Define '*end-point energy'*?
52. Show that β^- - decay is possible only if the mass of the parent atom is greater than the daughter atom.
53. Show that the electron capture is possible if and only if the mass of the parent atom is greater than the daughter atom by at least the binding energy of the electron.
54. Show how neutrino hypothesis explain the discrepancy and accounts for the continuous β −ray spectrum.
55. State some of important properties of neutrino.
56. Electrons do not exist inside the nucleus. Then what is the cause of β −decay?
57. What are the fundamental assumptions of Fermi's theory of β −decay?
58. Derive an expression for the β −disintegration energy.
59. What is meant by *internal conversion*?
60. What are γ −rays? How do they originate?
61. Discuss the absorption of γ −rays by the matter.
62. What are the main processes by which γ −rays get attenuated?
63. Distinguish between internal conversion and photoelectric effect.
64. What is internal conversion co-efficient?
65. What are isomers?
66. Give an idea about (a) pair-production and (b) electron-positron annihilation.
67. Can one expect pair-production in vacuum?
68. What is nuclear reaction?
69. Mention the various conservation laws in a nuclear reaction? Name also the physical quantities which are not conserved in a nuclear reaction.
70. Define Q-value of a nuclear reaction.
71. What are exothermic and endothermic nuclear reactions?

72. Define threshold energy of an endothermic nuclear reaction.
73. Derive an expression for the Q-value considering the recoil of a stationary target X with a projectile x.
74. Derive an expression for the threshold energy of an endoergic nuclear reaction.
75. What is separation energy? Find its expression.
76. Outline Bohr's compound nucleus hypothesis to explain the nuclear reaction.
77. The same compound nucleus can be formed by a number of different ways-explain.
78. What is artificial or induced radioactivity? What are radio-isotopes? Mention some of its applications.
79. Give examples of nuclear reaction induced by α −particle, $protons$, deuterons, neutron and γ −rays.
80. Define *nuclear fission*.
81. What are spontaneous or auto fission? Give an example.
82. What is induced fission? Give an example.
83. Explain the process of nuclear fission on the basis of liquid drop model also find the condition for nuclear reaction.
84. What is nuclear chain reaction?
85. What is a nuclear reactor?
86. What are the basic and essential components of a nuclear reactor?
87. What is the working principle of a nuclear reactor?
88. What are prompt and delayed neutrons? Explain the significance of delayed neutron with reference to nuclear fission.
89. Explain the followings: (a) moderator, (b) Control rods
90. Discuss about the classification of nuclear reactors.
91. What are fast, intermediate, thermal, slow neutrons and cold neutrons?
92. At what rate will U-235 be consumed by a reactor operating at an output of 100 kW?
93. At what power level should a U-235 reactor operate in order to consume 2 kg of uranium in 30 days?
94. Calculate the useful power produced by a nuclear reactor of 40% efficiency if 10^{14} fission occur each and the energy per fission is 250 MeV.
95. The fission fragments must show β −activity to get rid of the excess neutrons-explain.
96. Give an estimate of the energy released during the nuclear fission of one U-235.
97. What are the four basic interactions in nature and also state about their relative strengths?
98. What is the role of particle accelerators in nuclear physics?
99. What are the essential components of a particle accelerator?
100. Discuss with the help of a neat sketch the construction of a Betatron and also explain its working.
101. Give the basic difference between a cyclotron and a Betatron.
102. What is a Synchroton? State its working principle. In what respect does it differ from that of a Betatron?
103. What are the various methods available to detect charged particles?
104. State the basic principle of construction of nuclear radiation detector.