Chapter-13

NUCLEI

One mark questions

1) Define atomic mass unit (amu). (U)
2) Write the value of 1 atomic mass unit in kilogram. (K)
3) Name the instrument used to measure the atomic masses. (K)
4) How is the radius of the nucleus of an atom related to its mass number? (U)
5) What is the radius of a nucleus of mass number 216? (A)
6) What is the order of the magnitude of nuclear density? (K)
7) How does the nuclear density depend on the size of the nucleus? (U)
8) Is the nuclear density same for all the elements? (K)
9) Give an example for mass-energy conversion. (U)
10) Give an example showing the conversion of energy into mass. (U)
11) What happens when an electron and a positron collide? (U)
12) What is the energy equivalent to 1amu? (K)
13) Who discovered neutron? (K)
14) Do free neutrons are stable? (K)
15) Define mass number of nucleus? (K)
16) How many isotopes gold has? (K)
17) What are isobars? (K)
18) What are isotones? (K)
19) What is nuclear mass defect? (U)
20) Write the expression for mass defect in terms of masses of their nucleons. (K)
21) What is nuclear binding energy? (U)
22) Give the relation between binding energy and mass defect. (K)
23) What happens to the loss of mass involved in the formation of a nucleus? (U)
24) Mention the significance of binding energy per nucleon of a nucleus. (U)
25) What is binding energy curve? (K)
26) What are nuclear forces? (K)
27) Why nuclear forces are strongest of all the forces in nature? (U)
28) Why nuclear forces are called short range forces? (U)
29) Why nuclear forces are called exchange forces? (U)
30) Nuclear forces are non-central forces Explain? (U)
31) Nuclear forces are saturated forces why? (U)
32) Which property of nuclear forces is responsible for constancy of binding energy per nucleon? (K)
33) Name the phenomenon by which energy is produced in star. (K)

34) Why nuclear fusion reactions are called thermo nuclear reactions? (K)
35) Write any one equation representing nuclear fusion reaction. (K)
36) Why nuclear fusion reaction is not possible in the laboratory? (K)
37) What is radioactivity? (K)
38) Who discovered the phenomenon of radio activity? (K)
39) How many types of radioactive decay occur in nature? (K)
40) What is the cause for the radioactivity in lighter nuclei? (U)
41) How does the number of radioactive atoms vary with time? (K)
42) Show graphically the variation or number of radioactive atoms in the sample with time. (S)
43) Define activity of radioactive substance. (U)
44) Mention the SI unit of activity. (K)
45) Define becquerel. (U)
46) Mention the practical unit of activity. (K)
47) Define curie. (U)
48) Write the equivalence between curie and becquerel. (K)
49) How does the half-life of a radioactive sample depend on its decay constant? (U)
50) Define mean life of a radioactive substance. (U)
51) Write the relation between mean life and half-life of a radioactive nuclide. (K)
52) What is disintegration energy or Q-value of a nuclear reaction? (U)
53) In which type of β-decay antineutrino is emitted? (K)
54) Which is the particle emitted along with electron, when a neutron is converted into a proton in a nucleus? (K)
55) In which type of β-decay, the particle neutrino is emitted? (K)
56) In the following nuclear reaction identify the particle X. (U)

$$p \longrightarrow n + e^{+} + X$$

57) Two nuclei have mass numbers in the ratio 8:125. What is the ratio of their nuclear radii? (A)
58) What is nuclear fission? (K)
59) What is the principle of nuclear reactor? (K)
60) Define' multiplication factor' in a nuclear reactor? (U)
61) For what value of 'k' the multiplication factor the operation of the reactor is said to be critical? (K)
62) Which moderators are commonly used in nuclear reactors? (K)
63) Mention the disaster which occurred due to increase of multiplication factor in a nuclear reactor. (K)
64) How nuclear reaction rate is controlled in a nuclear reactor? (K)
65) What is the function of control rods in a nuclear reactor? (K)
66) What is nuclear fusion? (K)
67) What is the estimated age of the sun based on nuclear reactions? (K)

Two mark questions

1. What are isotopes? Give an example of it. (K)
2. Name the isotopes of hydrogen and write their masses. (K)
3. What are isobars? Give an example. (K)
4. What are isotones? Mention an example of it. (K)
5. Do free neutrons are stable in nature? Justify your answer. (U)
6. What is meant by binding energy per nucleon? Explain. (U)
7. Nuclear forces are strongest forces in nature why? (U)
8. What are neutrinos? In which process they are obtained? (K)
9. Write any two characteristics of neutrinos. (K)
10. Where does the decay of proton to neutron take place? And why? (U)
11. State and explain radioactive decay law. (K)
12. Mention any two types of radioactive decay in nature. (K)
13. What is γ-decay? When does this occur? (U)
14. What is the change in atomic numbers and mass number of a nucleus when it emits an α-particle? (A)
15. What is the change in atomic number and mass number of a nucleus during negative β-decay? (A)
16. What is the change in atomic number and mass number of a nucleus during positive β-decay? (A)
17. What happens to the atomic number and mass number of the nucleus during a γ-decay?(A)
18. ${}_{92}U^{238}$ emits an α-particle and two β-particles. Write the atomic number and mass number of the daughter nucleus. (A)
19. The radioactive isotope D decays according to the sequence $D \xrightarrow{\beta-decay} D_1 \xrightarrow{\alpha-decay} D_2$

    If the mass number and atomic number of D_2 are 176 and 71 respectively find mass number and atomic number of D. (A)
20. Give examples for controlled and uncontrolled nuclear fission reactions. (K)
21. What happens to the future of the sun when the hydrogen burning stops? (U)
22. Define the terms (i) mass defect and (ii) binding energy of a nucleus. (U)

Three mark questions

1. Name the three isotopes of hydrogen and write their masses. (K)
2. Explain how neutrons were discovered. (U)
3. Mention any three characteristics of a nucleus. (K)
4. How the size of the nucleus is experimentally determined? Explain. (U)
5. Show that the density of the nucleus is independent of its mass number. (U)
6. Write any three characteristics or nuclear forces. (K)
7. Show graphically the variation of potential energy of a pair of nucleons as a function of their separation and explain. (S) ((U)
8. What is a binding energy curve? Explain the main features of it. (U)

9. What is radioactive decay? How many types of decay are there in nature? Which are they? (K)
10. What is nuclear fission? Explain with example. (U)
11. What is nuclear fusion? Explain with example. (U)
12. Arrive at the relation between activity and decay constant of a radioactive sample. (U)
13. Derive the expression for the half-life of a radioactive nuclide. (U)
14. Explain alpha decay by giving an example and when is it possible? (U)
15. Write three characteristics of neutrinos. (K)
16. What is negative β-decay? Explain with example. (U)
17. What is positive β-decay? Explain with example. (U)
18. What is γ-decay? Explain with example. (U)
19. Estimate the energy released during the fission of uranium. (A)
20. Explain how controlled chain reaction is sustained in the nuclear reactors. (U)
21. Draw a schematic labeled diagram of a nuclear reactor based on the thermal neutron fission. (S)
22. Explain why very high temperature is essential for fusion reaction. (U)

Five mark questions

1. Explain the characteristics of nucleus. (K)
2. What are the conclusions drawn by observing the binding energy curve? (U)
3. State radioactive decay law and arrive at $N = N_0 e^{-\lambda t}$ where the symbols have their usual meaning. (U)
4. Show graphically, the variation of binding energy per nucleon with the mass number and also explain how energy is released in the process of nuclear fission and nuclear fusion. (S) (U)
5. Distinguish between nuclear fission and nuclear fusion. (U)
6. Obtain the expression for the number of atoms present in a radioactive sample in a given instant of time. (U)
7. Define half-life of a radioactive element. Derive the expression for half of a radioactive element in terms of decay constant. (U)
8. Deduce the relation between half-life and mean life of a radioactive substance. (U)
9. Explain how electricity is generated in a nuclear reactor. (U)

Numerical Problems

1. One gram of a radioactive substance disintegrates at the rate of $3.7X10^{10}$ disintegrations per second. The atomic mass of the substance is 226. Calculate its mean life. **[2282 years]**
2. Find the binding energy of an α-particle from the following data.
   Mass of the helium nucleus=4.001265 a.m.u
   Mass of the proton = 1.007277 a.m.u
   Mass of the neutron = 1.00866 a.m.u (A) **[7.10525 MeV]**
3. Calculate the mass defect and specific binding energy of $_7N^{14.}$ Given: The rest mass of nitrogen nucleus is 14.00307 amu. Mp = 1.00783amu, M_n = 1.00867amu (A)
   [Ans: Δm = 0.11243 amu, S.BE = 7.*48 MeV*]
4. Calculate the energy of released in the following fusion reaction of 1Kg of $_1H^2$.
   $$_1H^2 +_1 H^2 \longrightarrow _2 He^3 +_0 n^1 + Q$$
   Given: Mass of $_2He^3$ = 3.0161amu, mass of $_1H^2$ = 2.0141amu and mass of neutron $_0n^1$ = 1.0087amu. (A) **[Ans: Q=4.769 X 10^{26}MeV]**
5. The half-life of a radioactive substance is 30s calculate i) the decay constant and ii) time taken to the sample to decay by 3/4th of the initial value? (A)
   [Ans: λ=0.0231 per sec, t=60 sec]
6. Calculate the half-life and mean life of Radium 226 of activity 1Ci; Given mass of Radium -226 gram and 226 gram of radium consists of 6.023×10^{23} atoms. (A)
   [Ans: T = 5 X 10^{10} Sec, τ = 7.2 X 10^{10} Sec]
7. The half-life of a radioactive element is 4×10^8 years.Calculate its decay constant and mean life. (A) **[Ans: λ = 1.733 X 10^{-9} Per Year, τ = 5.772 X 10^8 Years]**
8. Find the activity in curie of 1g of radon: 222, whose half-life is 3.825 days.
   Avogadro number = 6.023×10^{23}, given; 1 curie = 3.7×10^{10} disintegrations per second. (A)
   [Ans: R = 1.5375 X 10^5 Ci]
9. Determine the mass of Na^{22} which has an activity of 5mci. Half-life of Na^{22} is 2.6 years.
   Avogadro number = 6.023×10^{23} atoms**. (A)** **[Ans: m = 7.996 X 10^{-10} Kg]**
10. Calculate the mass in gram of radium 226. Whose activity is 1 curie and half-life is 1620 years.
    (Avogadro's number = 6.023×10^{23}) (A) **[Ans: m = 1.024 g]**

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