10. Nuclear and Particle Physics

Segment-1:

1. Energy released in the fission of a single $^{235}_{92}U$ nucleus is 200 MeV. The fission rate of a $^{235}_{92}U$ filled reactor operating at a power level of 5 W is:
   a) $1.56\times10^{-10}\,s^{-1}$ b) $1.56\times10^{-11}\,s^{-1}$
   c) $1.56\times10^{-16}\,s^{-1}$ d) $1.56\times10^{-17}\,s^{-1}$

2. A particle moving with a velocity of $1/100^{th}$ of that of light will cross a nucleus in about
   a) 10^{-8} sec b) 10^{-12} sec
   c) 10^{-17} sec d) 10^{-20} sec

3. If the speed of light were 1/3 of the present value, the energy released in a given atomic explosion will be decreased by a fraction.
   a) 2/3 b) 1/9
   c) 1/3 d) 8/9

4. The B.E. of two nuclei P^n and Q^{2n} are *x* joule and *y* joule respectively. If $2x > y$, then the energy released in the reaction $P^n + P^m = Q^{2n}$ will be.
   a) $2x + y$ b) $2x - y$
   c) xy d) $x + y$

5. Two nucleons are at a separation of 1 fm. The net force between them is F_1 if both are neutrons, F_2 if both are protons, and F_3 if one is a proton and the other is a neutron.
   a) $F_1 > F_2 > F_3$ b) $F_2 > F_1 > F_3$
   c) $F_1 = F_3 > F_2$ d) $F_1 = F_2 > F_3$

6. Order of magneitude of density of uranium nucleus is ($m_p = 1.67\times10^{-27}\,kg$)
   a) $10^{20}\,kg/m^3$ b) $10^{17}\,kg/m^3$
   c) $10^{14}\,kg/m^3$ d) $10^{11}\,kg/m^3$

7. Nuclear forces are
   a) Short ranged attractive and charge independent
   b) Short ranged attractive and charge dependent
   c) Long ranged repulsive and charge independent
   d) Long ranged repulsive and charge dependent

8. A nucleus ruptures into two nuclear parts which have their velocity ratio equal to 2:1. What will be the ratio of their nuclear size (nuclear radius)
   a) $2^{1/3} : 1$ b) $1 : 2^{1/3}$
   c) $3^{1/3} : 1$ d) $1 : 3^{1/3}$

9. The binding energy per nucleon of O^{16} is 7.97 MeV and that of O^{17} is 7.75 MeV. The energy (in MeV) required to remove a neutron from O^{17} is

a) 3.52 b) 3.64
c) 4.23 d) 7.86

10. Nuclear fusion of protons is possible due to
a) C – C cycle b) C – N cycle
c) N – N cycle d) None of these

11. Plasma consists of
a) only deuterouns b) deuterons, protons, tritons and electrons
c) nuclei of heavy elements d) halogen gases

12. Energy diagram for a fissionable nucleus

Figure

13. Semi empirical mass formula is also called as
a) The Weizsaecker formula b) Frank-Condon formula
c) Baldwin formula d) Gamow formula

14. According to liquid drop model the surface correction term is proportional to
a) A b) $A^{1/3}$
c) $A^{2/3}$ d) $A^{-2/3}$

15. According to liquid drop model the asymmetry energy term is negative and proportional to
a) $\frac{(A-2Z)^2}{Z}$ b) $\frac{(A-2Z)^2}{A}$
c) $\frac{(A-2Z)^2}{\sqrt{A}}$ d) $\frac{(A-Z)^2}{A}$

16. Direct reactions occur when
a) The projectile interacts primarily in the surface of the target nucleus
b) The projectile collides direct with target nucleus
c) The projectile touches the surface of the target nucleus
d) None of the above

17. If $Q > 0$ other reaction is
a) Exoergic reaction b) Endoergic or Endothermic reaction
c) Both (a) and (b) d) None of these

18. β^+ decay for a proton-rich nucleus is
a) Proton capture b) Electron capture
c) Neutron capture d) All of the above

19. Beta decay is the
a) Transformation of neutron to electron
b) Transformation of neutron to a proton or vice-versa
c) Transformation of electron to proton
d) Transformation of proton to electron

20. The packing fraction is zero for

a) ${}_6C^{12}$ b) ${}_6O^{16}$

c) ${}_6He^{4}$ d) ${}_7N^{14}$

21. The nuclear spin is equal to the geometric sum of the

a) Angular momentum of protons and neutrons
b) Angular momentum of electrons and neutrons
c) Linear momentum of proton
d) None of the above

22. Magnetic moment of proton and neutron are

a) $\mu_p = \frac{3}{2}\mu_N$, $\mu_n = 1.91\mu_N$ b) $\mu_p = 2.7\mu_N$, $\mu_n = 1.91\mu_N$

c) $\mu_p = 2.7\mu_N$, $\mu_n = -1.91\mu_N$ d) $\mu_p = \frac{1}{3}\mu_N$, $\mu_n = 1.91\mu_N$

23. If the binding energy is large

a) the nucleus is stable b) the nucleus is unstable
c) the nucleus ruptures d) can't say

24. The contribution of coulomb energy in the semi-empirical mass formula of a nucleus of mass number *A* and atomic number *Z* is of the form (*a* = constant)

a) $aZA^{2/3}$ b) $\frac{aZ\{(Z-1)\}}{A^{1/3}}$

c) $\frac{aZ\{Z+1\}}{A}$ d) $\frac{aZ^2}{A^{2/3}}$

25. In the semi-empirical formulae the observed parity of odd Z and odd N nuclei in nature is taken care of by the

a) Surface energy term b) Coulomb's energy term
c) δ-term d) Asymmetry term

26. In nuclei of Z < 20, the ratio of number of neutron to protons is

a) More than 1 b) Less than 1
c) Much greater than 1 d) Nearly equal to 1

27. The quadruple moment of the nucleus is a

a) Tensor b) Scalar
c) Vector d) None of these

28. Correct expression for total binding energy B of a nucleus ($a_1, a_2, a_3, a_4 > 0$)

a) $B = a_1A - a_2A^{2/3} - a_3\frac{Z(Z-1)}{A^{1/3}} - a_4\frac{(A-2Z)^2}{A} + \delta$

b) $B = a_1 A + a_2 A^{2/3} - a_3 \frac{Z(Z-1)}{A^{1/3}} - a_4 \frac{(A-2Z)^2}{A} + \delta$

c) $B = a_1 A + a_2 A^{2/3} + a_3 \frac{Z(Z-1)}{A^{1/3}} - a_4 \frac{(A+2Z)^2}{A} + \delta$

d) $B = a_1 A - a_2 A^{2/3} - a_3 \frac{Z(Z+1)}{A^{1/3}} - a_4 \frac{(A-2Z)^2}{A} + \delta$

29. The volume of a nucleus in a atom is proportional to the
    a) Mass number
    b) Proton number
    c) Neutron number
    d) Electron number

30. The mean momentum of a nucleon in a nucleus with mass number A varies as
    a) A
    b) A^2
    c) $A^{-2/3}$
    d) $A^{-1/3}$

31. The ratio of the sizes of $^{208}_{82}Pb$ and $^{26}_{12}Mg$ nuclei I approximately
    a) 1
    b) 4
    c) 8
    d) 16

32. The binding energy per nucleon is maximum for the nucleus
    a) ^{56}Fe
    b) ^{4}He
    c) ^{208}Pb
    d) ^{101}Mo

33. If the nuclear radius of 27 Al is 3.6 Fermi, the approximate nuclear radius of ^{64}Cu in Fermi is
    a) 4.8
    b) 3.6
    c) 2.4
    d) 1.2

34. Deuteron in its ground state has a total angular momentum J = 1 and a positive parity. The corresponding orbital angular momentum L and spin S combinations are
    a) L = 0, S = 1 and L = 2, S = 0
    b) L = 0, S = 1 and L = 1, S = 1
    c) L = 0, S = 1 and L =2, S = 1
    d) L = 1, S = 1 and L = 2, S = 1

35. The deuteron is known to be in a state with S = 1, J = 1, I = 0 where S, J, I refer to spin, total angular momentum and isospin quantum numbers respectively. The allowed values of the orbital angular momentum quantum number L are
    a) 0
    b) 0, 1, 2
    c) 1
    d) 0, 2

36. From meson filed theory the potential energy of interaction between two nucleons is proportional to
    a) $\frac{e^{-\mu r}}{r^2}$
    b) $\frac{e^{-\mu r}}{r}$
    c) $\frac{e^{-\mu r^2}}{r^2}$
    d) $\frac{e^{-\mu r^2}}{r}$

37. To explain the observed magnetic moment of a deuteron ($0.8574\,\mu_N$) its ground state wave function is taken to be a mixture of S and D states. The expectation values of the Z-component of the magnetic moment in pure S and pure D states are $0.8797\,\mu_N$ and $0.310\,\mu_N$ respectively. The contribution of the D state to the mixed ground state approximately is
    a) 40% b) 4%
    c) 0.4% d) 0.04%

38. The ground state of the deuteron is a
    a) Pure $^3S_1$ state b) Pure $^3P_1$ state
    c) Mixture of $^3S_1$ and $^3P_1$ states d) Mixture of $^3P_1$ and $^3D_1$ states

39. An admissible potential between the proton and the neutron in a deuteron is
    a) Coulomb b) Harmonic oscillator
    c) Finite square well d) Infinite square well

40. The spin and parity of $_4Be^9$ nucleus, as predicted by the shell model, are respectively
    a) $3/2$ and odd b) $1/2$ and odd
    c) $3/2$ and even d) $1/2$ and even

41. The nucleus ^{41}Ca can be described by the single particle shell model– The single particle states occupied by the last proton and the last neutron, respectively, are given by
    a) $d_{5/2}$ and $f_{7/2}$ b) $d_{3/2}$ and $f_{5/2}$
    c) $d_{5/2}$ and $f_{5/2}$ d) $d_{3/2}$ and $f_{7/2}$

42. Using data of 56, the ground state angular momentum and parity of ^{41}Ca are
    a) $\frac{7^-}{2}$ b) $\frac{3^+}{2}$
    c) $\frac{5^+}{2}$ d) $\frac{5^-}{2}$

43. According to the shell model, the ground state $^{15}_8O$ of nucleus is
    a) $\frac{3^+}{2}$ b) $\frac{1^+}{2}$
    c) $\frac{3^-}{2}$ d) $\frac{1^-}{2}$

44. The nuclear spins of $_6C^{14}$ and $_{12}Mg^{25}$ nuclei are respectively
    a) Zero and half integer b) Half-integer and zero
    c) An integer and half-integer d) Both half-integers

45. The number of hyperfine components observed in the electronic transition $^2P_{1/2} \rightarrow {}^2S_{1/2}$ of an atom with nuclear spin $1/2$ is
    a) 3 b) 4
    c) 6 d) 5