Physics C.E.T Questions

Topics :- Nuclear Physics

Radioactivity

Scattering of Light

Elementary Particles

Synopsis

Nuclear physics

1. Nucleus consists of protons and neutrons which are collectively called as nucleons.

Mass of proton

$m_p = 1.67208 \times 10^{-27}$ kg

$= 1.00728$ a.m.u

Mass of neutron

$m_n = 1.67431 \times 10^{-27}$ kg

$= 1.00865$ a.m.u

Charge on the proton = 1.6 x 10^{-19}C

Neutron has no charge.

Nucleus of an element X is denoted by $_{Z}X^{A}$ where Z = atomic number and A = mass number.

2. a) Nuclear radius, $R = R_0 A^{1/3}$ where

R_0 = 1.3 fermi.

b) Nuclear size: It is of the order of

1 fermi = 10^{-15}m.

c) The size of the atom is of the order of $1A^0 = 10^{-10}$m.

3) Nuclear mass = $Z\,m_p + (A-Z)\,m_n$

4) Nuclear density = $\dfrac{\textit{nuclear mass}}{\textit{nuclear size}}$

$$\rho = 3m_p / 4\pi R_0^3$$

It is of the order of 10^{17} kgm^{-3} and is independent of mass number.

5) Types of nuclei: Isotopes, Isobars, Isomers, Mirror Nuclei- $_4Be^7$(Z=4,N=3) $_3Li^7$(Z=3,N=4)

6) Forces between nucleons:

Electrostatic forces -between protons only,

Tensor forces - are due to spinning of nucleons

Hard core forces - arises when the distance between nucleons is 0.5 fermi. Due to these forces density of nucleus remains constant.

Nuclear forces - between any two nucleons

Characteristics of nuclear forces

They are attractive, short ranged, saturated, strongest and charge independent but spin dependent forces.

According to Yukawa, they are due exchange of π^+ π^- π^0 mesons between the nucleons.

7) Atomic mass unit (a.m.u.)

1 a.m.u = $\frac{1}{12}$ th the mass of 1 atom of C^{12} isotope.

1 a.m.u. = 1.66×10^{-27} kg.

8) **Electron Volt (eV):** 1eV = 1.66 x 10^{-19}J

9) **Mass energy equivalence:** $E = mc^2$

The amount of energy equivalent of 1a.m.u = 931 Mev. The amount of energy released when an electron is annhilated is 0.51Mev.

10) Mass defect:

$$\Delta m = [\, Zm_p + (A-Z)m_n \,] - M$$

where M = actual mass of the nucleus.

11) Binding energy (B.E):

Binds the nucleons together inside the nucleus. S.B.E = Binding energy / nucleon. It is a measure of stability of a nucleus.

12) Packing fraction: $P = \frac{M - A}{A}$

13) Nuclear Fission:

$$_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}_{92}U^{236} \longrightarrow X + Y + \text{neutrons} + Q \text{ (energy)}$$

where X & Y are fission fragments.

Average number of neutrons produced is 2 to 3.

Average energy released per fission of $_{92}U^{235}$ is about

200 Mev = 3.2×10^{-11}J

Energy released in the fission of 1 kg of $_{92}U^{235}$ is 8×10^{13}J.

14) **Nuclear Chain reaction:**

Controlled N.C.R (Nuclear reactor).

Uncontrolled N.C.R (Atom bomb).

15) **Nuclear reactor**:- It consists of 6 main elements:

a) Fuel (Pu^{239}, U^{235})

b) Moderator(D_2O, Be)

c) Control Rods(Cd,B)

d) Coolant(water)

e) Shield

f) Reflectors

First Indian nuclear reactor is APSARA.

Nuclear reactor was first devised by **FERMI** in 1942.

Types of Nuclear reactor:

a) Power reactor

b) Breeder reactor

c) Research reactor

16) Nuclear Fusion:

$${}_1H^2 + {}_1H^2 \longrightarrow {}_2He^4 + 25\ \text{Mev.}$$

As it occurs at a very high temperature of the order of 10^7K to 10^8 K, it is called thermonuclear reaction.

17) Stellar energy: It is the energy released by stars like Sun.

Source of Stellar energy:

a) Carbon – Nitrogen cycle (CNC)

Stars hotter than Sun emit energy by Carbon- Nitrogen cycle.

b) Proton - proton cycle (PPC)

Stars cooler than Sun emit energy by PPC

More energy is released in PPC than CNC.

In either case, the overall process is

$$4\,{}_{1}H^{1} \longrightarrow {}_{2}He^{4} + 2\,{}_{+1}e^{0} + 26.7\text{ Mev (PPC)}$$

$$25.7\text{ Mev (CNC)}$$

The catalyst is Carbon in Carbon-Nitrogen cycle.

RADIOACTIVITY (Roentgen in 1896)

All elements with Z > 82 are radioactive.

Eg: $_{92}U^{238}$, Po, Ra, etc.

Types of Radioactive rays:

$i) \propto - rays$

$ii) \beta - rays$

$iii) \gamma - rays$

Group Displacement law:

$${}_{z}X^{A} \longrightarrow {}_{z-2}Y^{A-4} + {}_{2}He^{4} \text{ (particle)}$$

$${}_{z}X^{A} \longrightarrow {}_{z+1}Y^{A} + {}_{-1}e^{0} \text{ (particle)}$$

Rate of decay (activity) $\frac{dN}{dt} = -\lambda N$

Decay law: $N = N_o e^{-\lambda t}$

where λ is decay constant

Half life:

$$T_{1/2} = \frac{0.693}{\lambda}$$

Mean life: $T_{av} = \frac{1}{\lambda}$

$$T_{\frac{1}{2}} = 0.693\,Tav$$ or $$Tav = 1.44T_{\frac{1}{2}}$$

6) No. of atoms (N) remaining after n lives in the sample is $N = 1/2^n N_0$ where N_0 = initial number of atoms.

7) Activity of a radioactive substance:

$$A = \frac{dN}{dt} = -\lambda N \;\;\&\; A = A_0 e^{-\lambda t}$$

where A_0 is the initial activity and A is the activity after time 't'.

Units of Radioactivity:

1 curie (1 ci) = 3.7 x 10^{10} dis/sec

1 Becquerel (1bq) = 1 dis/sec

(SI Unit of activity)

1 Rutherford =1 rd = 10^{6} dis/sec

Artificial Radioactivity:

$$_{13}Al^{27} + {}_{2}He^{4} \longrightarrow {}_{15}P^{*30} + {}_{o}n^{1}$$

$$_{15}P^{*30} \longrightarrow {}_{14}Si^{30} + {}_{1}e^{o} \text{ (Positron)}$$

Here radiophosphorus is a radio isotope and its half life ($T_{1/2}$) is 2.5 min.

Most important Radioisotopes and their uses :-

Radio P^{32} is used in leukemia, skin cancer.

Radio I^{131} is used for the treatment of thyroid gland

Radio Na^{24} is used in blood circulation disorder.

Radio Co^{60} is used in treating cancer.

Radio C^{14} is used to determine the age of fossils and antiques.

Radio Fe^{59} is used to examine anemia

Scattering of light

When light is incident on very small molecules of the medium, it is re emitted in all directions. This phenomenon is called as scattering of light.

According to Rayleigh theory,

Intensity of scattered light is inversely proportional to fourth power of its wavelength and is given by $I \propto \frac{1}{\lambda^4}$

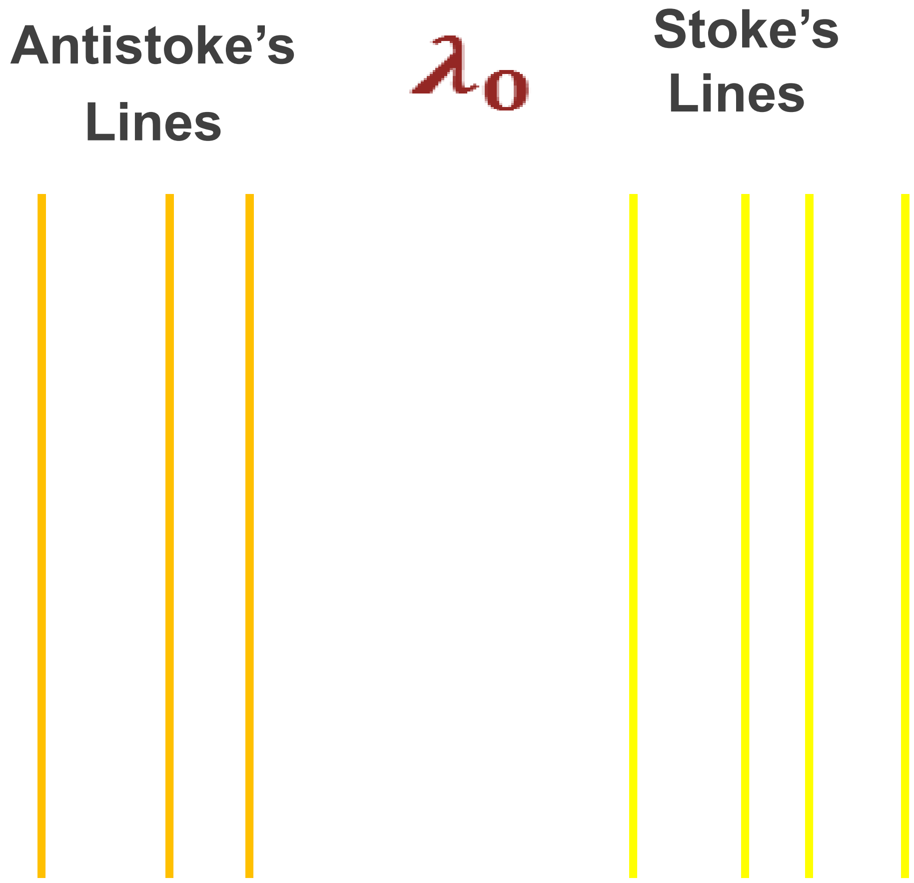
This shows that larger is the wavelength, lesser is the scattering. Hence blue scatteres the most while red the least.

Blue colour of the sky and the sea, reddish colour of the sun at sunset or sunrise, clouds appear white, are due to scattering of light.

Types of scattering:

1. Coherent or elastic scattering.
2. Incoherent or inelastic scattering.

Raman Effect : When an intense beam of monochromatic light is passed through some organic liquids (Benzene, Toluene) the scattered observed at right to the incident beam found to consists frequencies other than that of incident light. This is called Raman Effect.



RAMAN SPECTRUM

Elementary Particles

- **Hadrons**
  - **Baryons**
    - Proton
    - Neutron
    - Lambda
    - Sigma
    - Omega
  - **Mesons**
    - Pions
    - Kaons
    - Eta
- **Leptons**
  - Photon
  - Electron
  - Neutrino
  - Muon

1. The repulsive force between the positively charged protons does not throw them apart, because

    1) Nuclear force is stronger
    2) Neutrons exist between protons
    3) Coulombian force does not act at small distances
    4) due to other reasons other than mentioned above

Ans: 1

Electrostatic force is lesser than nuclear force between the two positively charged protons.

2. The approximate ratio of nuclear densities of ${}_{26}Fe^{56}$ and ${}_{92}U^{238}$ is ________

1) 0
2) ∞
3) 1
4) none of these

Ans: 3

From the relation $\rho = \frac{3m}{4\pi R_0^3}$

it is clear that ρ is same for all nuclei.

3. In each fission of $_{92}U^{235}$ releases 200 Mev of energy. How many fissions must occur per second to produce a power of 1 KW ?

1) 1.25×10^{18}
2) 1.25×10^{13}
3) 3.125×10^{13}
4) 3.2×10^{8}

Ans: 3

From the relation $P = \frac{nE}{t}$

we have

$$n = \frac{Pt}{E} = \frac{1000 \times 1}{200 \times 1.6 \times 10^{-19}}$$

$$n = 3.125 \times 10^{13}$$

4. In nuclear fission, 0.1% of mass is converted into energy. The energy released by the fission of 1kg mass will be ______ J

1) 9×10^{19}
2) 9×10^{17}
3) 9×10^{16}
4) 9×10^{13}

Ans: 4

Solution : we know that

$$E = mc^2 \quad = \frac{0.1 \times (3 \ \times 10^8)^2}{100}$$

$$E = 10^{-3} \times 9 \times 10^{16}$$

$$E \ = 9 \times 10^{13} \ \text{J}$$

5. The total binding energies of $_{1}H^{2}$, $_{2}He^{4}$, $_{26}Fe^{56}$ and $_{92}U^{235}$ are 2.22, 28.3, 492 and 786 Mev respectively. Which of the following nucleus is most stable?

1) $_{2}He^{4}$
2) $_{1}H^{2}$
3) $_{92}U^{235}$
4) $_{26}Fe^{56}$

Ans: 4

Solution : $\boldsymbol{SBE = \frac{BE}{A}}$

$$\frac{2.22}{2} = 1.11, \qquad \frac{28}{4} = 7,$$

$$\frac{786}{235} = 3.345 \qquad \frac{492}{56} = 8.7857$$

6. Thermal neutrons are those which

1) are at very high temperature
2) move with high velocities
3) have kinetic energies similar to those of surrounding molecules
4) are at rest

Ans : 3

Explaination : Thermal neutrons are slow neutrons which are in thermal equilibrium with their surrounding nuculei and have average energy of

$$\frac{1}{2}KT = 0.04 \text{ Mev}$$

7. What is nuclear holocaust?

1) Formation of nuclear bomb

2) Nuclear atmosphere

3) Making holes in metallic case by nuclear radiations

4) The aftermath of an atomic explosion.

Ans: 3

Explanation : Large scale destruction and destavation produced by the usage of nuculer weapons is the meaning of nuclear holocaust.

8. The critical mass of uranium is…

1) minimum mass needed for chain reaction
2) 1 kg equivalent
3) 75 kg
4) the rest mass is equivalent to 10^{20} joules.

Ans: 1

The size of fissionable material need for steady or sustained NCR so that K (Reproduction factor) = 1.

If K > 1, the stage is super critical leads in explosion.

If K < 1 , subcritical, the chain reaction gradually stops.

Neutron Multiplication factor,

$$K = \frac{\text{rate of neutron production}}{\text{rate of neutron loss}}$$

9. When $_5B^{10}$ is bombarded by neutron, α - particles are emitted. The mass number of the resulting nucleus is ……………

1) 15
2) 11
3) 7
4) 6

Ans: 3

Solution :

$$_5B^{10} + _0n^1 \rightarrow x^n + _2He^4$$

$$10 + 1 = n + 4$$

$$n = 11 - 4 = 7$$

10. The fusion occurs at high temperature because

1) atoms are ionized at high temperature

2) molecules breakup at high temperature

3) nuclei break up at high temperature

4) kinetic energy is high enough to over come the repulsion between nuclei.

Ans: 4

Explaination : High energy is required to merge nuclei

11. C^{14} decays with a half life of about 5800 years. In a sample of bone, the ratio of C^{14} to C^{12} is found to be $\frac{1}{4}$ th of what it is in free air . This bone may belongs to a period about x centuries ago, where x is nearest to

1) 2 x 58

2) 58

3) 58/2

4) 3 x 58

Ans: 1

Let the sample be 't' years old or n half life of C^{14}

$\therefore$ Amount of C^{14} at the end of 't' years = $1/2^n$ amount of C^{14}

$\Rightarrow 1/2^2 = 1/2^n \Rightarrow n = 2$

$\therefore t =$ n half life $= n \times T_{1/2}$

$\therefore t = 2 \times 5800$ yrs $= 2 \times 58$ centuries

12. T_1 and T_2 are the half lives of two radioactive elements of decay constants λ_1 and λ_2 respectively Then the value of T_1/T_2 is -----

1) $\lambda_2 = \lambda_1$
2) $\lambda_1 - \lambda_2$
3) λ_1 / λ_2
4) λ_2 / λ_1

Ans: 4

As $T_{1/2} \alpha 1/\lambda$

$T_1/T_2 = \lambda_2/\lambda_1$

13. A radioactive element has a half life of 1 day. Then 1000 atoms of the element reduce to 125 atoms in ______ days

1) 3
2) 4
3) 8
4) 125

Ans : 1

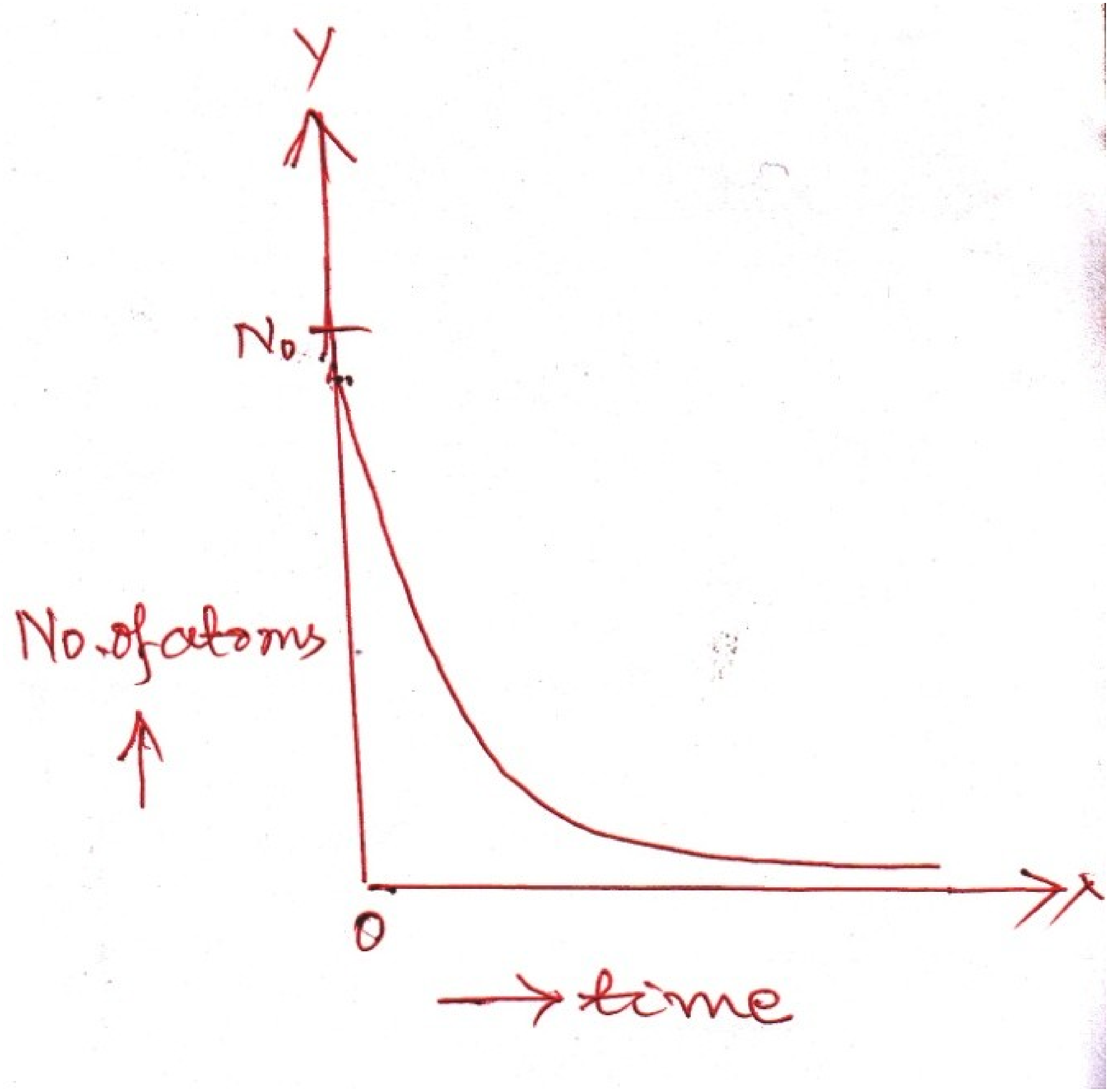
$$N = 1/2^n \, No$$

$$1/2^n = N_o/N = \frac{1}{8} = \frac{1}{2^3}$$

$$\boxed{n = 3}$$

14. Rate of decay of a radioactive substance changes with time

1) linearly
2) logarithmically
3) exponentially
4) none of these


Y
No
No. of atoms
0
X
time

15. If T is half is the half life of a radioactive element, time taken for N atoms in a sample to decay is ---------

1) 1000
2) ∞
3) NT
4) T/N

Ans : 2

It will take infinite time to decay completely

16. The number of α and β particles emitted in the reaction $_{92}U^{238} \rightarrow {}_{82}Pb^{206}$ respectively is _____ and _____

1) 8,6
2) 6,8
3) 8, 10
4) 8, 8

Ans : 1

Explanation

No. of α particles emitted = 8

Due 8 α , emitted charge of end products is (92-16) = 76

$\therefore$ There should be (82 - 76) = 6 β particles emitted

17. After certain lapse of time, the fraction of radioactive polonium is found to be 12.5% of initial quantity. If the half life of polonium is 138 days, then duration of time lapse is -------- days

1) 34.5
2) 276
3) 414
4) 125

Ans : 3

$$N/N_o = 1/2^n$$

$$(12.5/100)^3 = 1/8$$

$$1/2^n = \;= 1/2^3$$

$$\therefore \boxed{n = 3}$$

$\therefore$ **Duration of time lapse = 3T = 3 (138)**

= 414 days

18. Mean life of a radioactive element is 1 year. Then it's half life (in years) is ______

1) 0.8
2) 1
3) 0.693
4) 0.5

Ans : 3

$$T_{1/2} = 0.693/\lambda = 0.693\,T_{av}$$

$$\therefore T_{1/2} = 0.693 \times 1 = 0.693$$

19. β - decay means emission of electron from

1) radioactive nucleus
2) inner most electron orbit
3) a stable nucleus
4) outer most electron orbit

Ans : 1

β - decay means emission of electron from radioactive nucleus.

20. In a radioactive disintegration , the ratio of initial number of atoms to number of atoms present at an instant of time equal to its mean life is

1) e^2
2) $1/e^2$
3) $1/e$
4) e

Ans : 4

We know that $t = \tau = 1/\lambda$

$$N_t = N_0\, e^{-\lambda t} = N_0\, e^{-\lambda \times (1/\lambda)} = N_0 / e$$

$$\therefore N_0 / N_t = e$$

21. Scattering of light by smoke is an example of ---------

1) Tyndall scattering
2) Incoherent scattering
3) Raman effect
4) all these

Ans : 1

It is a scattering of molecules of turbid medium

22. According to Rayleigh the intensity of scattered light is inversely proportional to ____

1) λ^2
2) λ^3
3) λ^{-4}
4) λ

Ans : 3

According to Rayleigh

$\therefore I \propto 1/\lambda^4$

23. During Rayleigh scattering, the most scattered colour is --------

1) Blue
2) red
3) violet
4) yellow

Ans : 3

$\therefore I \alpha 1/\lambda^4$

As $\lambda_v < \lambda_b < \lambda_y < \lambda_r$

Intensity is more for Violet Colour

24. A composite beam of light containing wavelengths 440 nm and 550 nm is passed through a gas. In a given direction, the ratio of intensity of scattered light of those wavelengths will be

1) 125 : 256
2) 256 :125
3) 256 : 625
4) 625 : 256

Ans : 4

$$I_1/I_2 = (\lambda_2/\lambda_1)^4 = (550/440)^4$$

$$I_1/I_2 = (5/4)^4$$

$$I_1/I_2 = 625/256$$

25. Raman frequency is found to be dependent on --------

1) intensity of light
2) scattering medium
3) direction of observation
4) incident frequency

Ans : 2

Raman frequency depends on the nature of the medium in which the light is scattered.

26. Which of the following is not an optical phenomena?

1) Fluoroscence
2) Phosphorescence
3) Raman effect
4) Zener effect

Ans : 4

Zener effect is not an optical phenomena while the other three are optical phenomena .

27. The incorrect statement of the following is

1) Stoke lines and anti stoke lines are polarised
2) Stoke lines are more intense than anti stoke lines
3) Stoke lines have wavelength greater than that of incident light
4) The intensity of stoke lines found to depend on temperature

Ans : 4

Intensity of the stoke lines does not depends on temperature .

28. An electron is

1) A nucleon
2) A lepton
3) Hadron
4) Baryon

Ans : 2

It is a knowledge based question.

Electron belongs to the family of leptons.

29. Two protons are kept at a separation of 40 Å. F_n is the nuclear force and F_e is the electrostatic force between them. Then

1) $F_n \approx F_e$
2) $F_n << F_e$
3) $F_n = F_e$
4) $F_n >> F_e$

Ans : 2

Nuclear forces exists only when the distance is of the order of f_m (10^{-15} m) or less. Since the separation between two protons is given to be 40 Å, the nuclear force F_n does not exist.

30. The most stable particle in Baryon group is

1) lambda – particle
2) proton
3) omega – particle
4) neutron

Ans : 2

It is a knowledge based question.

The most stable particle in baryon group is proton .

31. Elementary particles that are weakly interacting are called --------

1) leptons
2) hyperons
3) positrons
4) mesons

Ans : 1

It is a knowledge based question.
Leptons interact weakly.

32. The particle that account for the missing energy and momentum during β – decay is

1) leptons
2) hadrons
3) neutrino or anti neutrino
4) none of these

Ans : 3

Neutrino or anti neutrino is emmitted during β – decay which accounts for the loss of energy and momentum .

33. There are ---------- types of leptons exist

1) 3
2) 4
3) 5
4) 6

Ans : 4

It is a knowledge based question.

There are 6 types of leptons.

34. The spins of protons, neutrons and electrons are all ---------

1) 0
2) 1
3) 2
4) 1/2

Ans : 4

It is a knowledge based question. Protons, Neutrons and Electrons have spin equal to ½ .

35. The various types of quarks are collectively called ________

1) leptons
2) hadrons
3) strange particles
4) flavors

Ans : 4

It is a knowledge based question.

Various types of quarks are collectively called Flavours.

Quarks family also contain 6 members.

36. Which of the following is most unstable ?

1) Proton
2) Free neutron
3) Electron
4) alpha particle

Ans 2:

Free neutrons are unstable and they undergo β – decay

37. The atoms of same element having different masses but same chemical properties are called

1) Isotopes

2) Isobars

3) Isotones

4) Isomers

Ans : 4

Explanation : Nuclei which have same Z and same A but differ from one another in their nuclear energy state and in their internal structure are called isomers.

38. When an electron and a positron collide ________

1) They repel each other
2) part of mass is converted into energy
3) the total mass is converted in to energy
4) the mass in not converted in to energy.

Ans: 3

Explanation : Energy released manifests as

$$E = 2m_eC^2$$

39. A nuclear reactor using U^{235} has a power of 1W. Number of uranium atoms undergoing fission per second is

1) 3×10^9
2) 10^6
3) 3×10^{10}
4) 3×10^8

Ans : 3

Energy released per fission = 1W = $1 Js^{-1}$

i,e, n x 200 mev = $1\ Js^{-1}$

$\Rightarrow n \times 2 \times 10^{2} \times 10^{6} \times 1.6 \times 10^{-19} = 1$

$\Rightarrow n \times 3.2 \times 10^{-11} = 1$

Hence, $n = 1/3.2 \times 10^{11} = 0.3125 \times 10^{11}$

$\therefore n = 3.125 \times 10^{10} \approx 3 \times 10^{10}$

40. An atom has mass number 14 has a packing fraction of 0.0002. The mass of the atom is ____

1) 14.028
2) 14.0028
3) 13.72
4) 18.42

Ans : 2

$$\text{Packing fraction (PF)} = M - A / A$$

$$M - A = PF \times A = 0.0002 \times 14$$

$$M - A = 0.0028$$

$$\therefore M = 0.00028 + A = 0.00028 + 14$$

$$\therefore M = 14.0028$$

41. When an α - particle is accelerated by a p. d of 1V, the energy gained by it is ______ ev

1) 4
2) 1
3) 2
4) 0.5

Ans : 3

We know that $W = qV$

$\Rightarrow W = 2 \times 1.6 \times 10^{-19} J \times 1$

$\therefore W = 2eV$

42. Energy released due to annihilation of 1 mg of matter is ---------- J

1) 9×10^{10}
2) 9×10^{16}
3) 3×10^{16}
4) 9×10^{8}

Ans : 1

$$E = mc^2 = 10^{-6} \times (3\times10^8)^2$$

$$E = 10^{-6} \times 9 \times 10^{16}$$

$$E = 9 \times 10^{10}\ J$$

43. Neutrons are more effective than protons as projectile to induce nuclear reaction because

1) protons are less stable
2) neutrons are more penetrating
3) neutrons have no charge
4) none of the above

Ans : 3

($\therefore$ they have no charge)

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