PHYSICS

BOOKS - MODERN PUBLISHERS PHYSICS (HINGLISH)

NUCLEI

Solved Examples

1. Natural chlorine is composed of two isotopes $_{17}Cl^{35}$ and $_{17}Cl^{37}$ with masses 34.968 and 36.968, respectively. If their relative abundance are 75.18% and 24.22% respectively, calculate the composite atomic mass of the natural chlorine.

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2. The natural lithium is composed of two isotopes of $_3Li^6$ and $_3Li^7$. The isotopes have masses 6.015121 amu and 7.016003 amu, respectively. Calculate the relative abundance of each isotope in the natural lithium if the atomic mass of natural lithium is 6.94 amu.

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3. Calculate the radius of nucleus of atom $_{95}Tc$ (Tc is the symbol for element technetium).

Given, nuclear unit radius, $R_0 = 1.1 fm$.

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4. The nuclear mass of $_{13}Al^{26}$ is 26.9815 amu. Find its nuclear density.

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5. Calculate the mass of $_6C^{13}$ atom. Take 1 amu $\times c^2 = 931 MeV$.

6. Calculate the equivalent energy for 15 mg of mass.

7. Calculate the number of electron volts in one joule.

8. Calculate the binding energy of an α-particle in MeV Given : m_p (mass of proton) = 1.007825 amu, m_n (mass of neutron) = 1.008665 amu Mass of the nucleus `=4.002800 amu, 1 amu = 931 MeV.

9. Calculate the binding energy per nucleon in the nuclei of $_{.15} P^{31}$. Given $m(_{.15} P^{31}) = 30.97376u$, $m(_{.0} n^1) = 1.00865u$, $m(_{.1} H^1) = 1.00782u$.

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10. How may $\alpha-$ and $\beta-$ particles will be emitted when $_{.90} Th^{232}$ changes into $_{.82} Pb^{208}$?

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11. After a certain lapse of time, fraction of radioactive polonium undecayed is found to be 12.5% of the initial quantity. What is the duration of this time lapsed if the half life of polonium is 138 days ?

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12. Radon has 3.8 days as its half-life . After how many days 25% of a radon sample remains undecayed ?

13. Calculate the half life period of a radioactive substance if its activity drops to $\dfrac{1}{16}$ th of its initial value in 30 years.

14. The half-life of $_{72}Au^{198}$ is 2.7 days. How much Au will be left out of 100 mg after 16.2 days'?

15. In a given radioactive sample, it is observed that after 415.8 days, 12.5% of the initial sample remains undecayed. Calculate the mean life and

decay constant of this sample.

16. Half-life of radium is 1,620 years. After how many years 0.75 mg of radium will be disintegrated out of its initial mass of 1 mg.

17. The half life of radon is 3.8 days . After how many days will only one twentieth of radon sample be left over ?

18. A radioactive material is reduced to $\dfrac{1}{16}$ of its original amount in 4 days. How much material should one begin with so that $4 \times 10^{-3} kg$ of the material is left over after 6 days ?

19. Calculate the half-life of uranium if its initial mass of 1 g is reduced by 2 mg in 5 years by disintegration into thorium and an α -particle.

20. An observer in a laboratory starts with N_0 nuclei of a radioactive sample and keeps on observing the number (N) of leftover nuclei at regular intervals of 10 minutes each. She prepares the following table on the basis of her observation.

Time (t) (in min.)	0	10	20	30	40
$\log e \left(\dfrac{N_0}{N} \right)$	0	3.465	6.930	10.395	13.860

Use this data to plot a graph of $\log_e (N_0 / N)$ vs time (t) and calculate the

(a) decay constant

(b) half-life of the given sample.

21. The half life of $_{.92}U^{238}$ against α decay is $1.5 \times 10^{17}s$. What is the activity of the sample of $_{.92}U^{238}$ having 2.5×10^{21} atom?

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22. The half-life of $_{54}Po^{210}$ is 140 days. What amount of $_{54}Po^{210}$ is required to provide source of a-particles of 10 mCi strength?

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23. What will be the activity of 0.5 g sample of $_{92}U^{238}$ if its half-life against a-decay is 1.5×10^{17} s?

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24. Two isotopes of lanthanum, one stable (^{139}La) and another active (^{138}La) are having a half-life of 10^{10} years. I f the atoms of active isotope

are 0.1% of the stable isotope, then estimate the activity of ^{138}La with 0.5

kg of ^{139}La

25. A slow neutron strikes a nucleus of $_{.92}U^{235}$ splitting it into lighter

nuclei of barium and krypton and releasing three neutrons. Write the

corresponding nuclear reaction. Also calculate the energy released on

this reaction

Given $m\left(_{.92}U^{235}\right) = 235.043933$ amum $\left(_{.0}n^{1}\right) = 1.008665$ amu

$m\left(_{.56}Ba^{141}\right) = 140.917700$ amum $\left(_{.36}Kr^{92}\right) = 91.895400$ amu

26. When a deuteron of mass 2.0141 a.m.u and negligible K.E. is absorbed

by a Lithium $\left(_{.3}Li^{6}\right)$ nucleus of mass 6.0155 a.m.u. the compound

nucleus disintegration spontaneously into two alpha particles, each of

mass 4.0026 a.m.u. Calculate the energy carried by each α particle.

27. Calculate the disintegration energy Q for fission of $._{42} Mo^{98}$ into two equal fragments $._{21} Sc^{49}$ by bombarding with a neutron. Given that $m\left(._{42} Mo^{98}\right) = 97.90541u, \; m\left(._{21} Sc^{49}\right) = 48.95002u, \; m_n = 1.00867u$

28. In a fission of single nucleus of $._{92}U^{258}$, about 200 MeV energy is released. How many fissions must occur to generate power of 10 kW?

29. What is the energy released by fassion of 1 g of U^{235}? (Assume 200 Me V energy is liberated on fission of 1 nucleus)

30. 200 MeV of energy is released when an atom of $_{92}U^{235}$ undergoes nuclear fission. A nuclear reactor using $_{92}U^{235}$ has an output of 800 MW. How many uranium atoms does it consume in one day? What mass of uranium does it consume each day?

31. Assuming that in a star, three alpha particle join in a single fusion reaction to form $_{.6}C^{12}$ nucleus. Calculate the energy released in this reaction. Given mass of $_{.2}He^4$ is 4.002604 a.m.u. and that of $_{.6}C^{12}$ is 12 a.m.u. Take 1a.m.u. =931MeV.

32. A star converts all its hydrogen to helium, achieving 100% helium composition. It then converts the helium to carbon via the reaction

$$_{.2}He^4 + _{.2}He^4 + _{.2}He^4 \rightarrow _{.6}C^{12} + 7.27MeV$$

The mass of the star is $5.0 \times 10^{32}kg$ and it generates energy at the rate

of 5×10^{30} watt. How long will it take to convert all the helium to carbon at this rate?

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Practice Problems

1. Calculate the nuclear density of $_{26}Fe^{54}$. Given that the nuclear mass of $_{26}Fe^{54}$ is 53.9396 amu.

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2. Given that the mass of carbon nucleus as 11.011 amu and A = 11, find the nuclear density.

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3. Determine the number of protons and neutrons in $_{92}U^{238}$ and $_{90}Th^{234}$.

4. Natural boron is a mixture of two isotopes $_5B^{10}$ and $_5B^{11}$ of masses 10.003 amu and 11.009 amu, respectively. Calculate the atomic mass of natural boron if the relative abundance of $_5B^{10}$ and $_5B^{11}$ is 19.97% and 80.03%, respectively.

5. Chlorine consists of the two isotopes $_{17}Cl^{35}$ and $'_{17}Cl^{37}$ of masses 34.99 amu and 36.97 amu, respectively. Calculate the relative abundance of each isotope if atomic mass of chlorine is 35.46 amu.

6. Calculate the effective mass of a photon with frequency of 6.2×10^{14} Hz.

7. Calculate the energy equivalent of 1g of substance.

8. Find the energy equivalent of one atomic mass unit, first in joule and then in MeV. Using this, express the mass defect of $._8 O^{16}$ in MeV/c^2. Given $M_p = 1.007825u$ and $M_n = 1.008665u$, $m_{oxy} = 15.99053$ a.m.u. and Take $1 a.\, m.\, u = 933.75 MeV/c^2$.

9. Calculate the mass defect of alpha particle in MeV/c^2 if mass of a-particle is 4.0039 amu.

10. Obtain the binding energy (in MeV) of a nitrogen nucleus $\left(^{14}_{7}N\right)$, given $m\left(^{14}_{7}N\right)$

$= 14.00307 \quad u$

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11. Determine the binding energy of $_3Li^7$ if its mass is 7.00 amu

Use 1 amu = 931 $MeVc^2(m_p = 1.007825u, m_n = 1.008665u)$.

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12. In a α -decay, the sequence is given as

$X \xrightarrow{\alpha} X_1 \xrightarrow{\beta} X_2 \xrightarrow{\alpha} X_3$. The mass number and atomic number of X are 170 and 62 respectively. Calculate the same values for X_3.

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13. In a process, $_{92}U^{238}$ is converted to $_{90}Th^{234}$. Determine the particles emitted in the process and also write the equation for the given process.

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14. By using the following atomic masses : $_{.92}^{238}U = 238.05079u.$ $_{.2}^{4}He = 4.00260u, _{.90}^{234}Th = 234.04363u.$ $_{.1}^{1}H = 1.007834, _{.91}^{237}Pa = 237.065121u$ (i) Calculate the energy released during the α – decay of $_{.92}^{238}U$.

(ii) Show that $_{.92}^{238}U$ cannot spontaneously emit a proton.

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15. Calculate the number of α- and β-particles emitted when $_{.92}U^{238}$ into radioactive $_{.82}Pb^{206}$.

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16. Half-life of a radioactive substance is 2.9 days. Calculate the amount of 10 mg of substance left after 29 days.

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17. A radioactive substance has decay constant of 0.231 day^{-1}. Calculate the percentage of the substance left after 6 days.

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18. Tritium has a half life of 12.5 years against beta decay. What fraction of a sample of pure tritium will remain undecayed after 25 years?

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19. A radioactive substance has a half-life of 1,700 years. Calculate the time taken for substance to reduce from one gram to one milligram.

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20. The radioactive substance $_{92}U^{238}$ has a half-life of 4.5×10^9 years. Determine the time taken for 3/4 of the substance to disintegrate.

21. A radioactive substance decays to $\left(\dfrac{1}{16}\right)^{th}$ of its initial activity in 40 days. The half-life of the radioacctive substance expressed in days is

22. Calculate the decay constant and time taken to decay by $\dfrac{7}{8}$ of initial value if its half-life is 10s.

23. A radioactive isotope has a half life of 5 yrs. How long will it take the activity to reduce to 3.125% ?

24. The half life of $._{92}U^{238}$ against α decay is $1.5 \times 10^{17}s$. What is the activity of the sample of $._{92}U^{238}$ having 2.5×10^{21} atom?

25. The half life of $._{92}^{238}U$ undergoing α-decay is 4.5×10^9 years. The activity of 1 g sample of $._{92}^{238}U$ is

26. A radioactive substances has half-life of 50 sec and activity of 5×10^{12} Becquerel. Calculate the time taken for activity to drop to 1.25×10^{12}.

27. A radioactive substance has a half-life of 10 hours. Calculate the activity of 10^{-10} gram of the substance after 2 hours if its atomic mass is 102.

28. A radioactive sample's activity drops to its one-third value in 80 minutes. Calculate the half-life of the sample.

29. A nucleus $_{10}Ne^{23}$ undergoes β- decay and becomes $_{11}Na^{23}$. Calculate the maximum kinetic energy of electrons emitted assuming that the daughter nucleus and antineutrino carry negligible kinetic energy. Given mass of $_{10}Ne^{23}$ = 22.994466 u and mass of $_{11}Na^{23}$ = 22.989770 m

30. We are given the following atomic masses:

$$_{93}Pu^{238} = 238.04954u$$

$$_{92}U^{234} = 234.04096u$$

$$_{2}He^{4} = 4.00260u$$

Calculate the kinetic energy associated with the alpha particle emitted during the conversion of $_{94}Pu^{238}$ into $_{92}U^{234}$

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31. In beta decay, $_{10}Ne^{23}$ is converted into $_{11}Na^{23}$. Calculate the maximum kinetic energy of the electrons emitted, given atomic masses of $_{10}Ne^{23}$ and $_{11}Na^{23}$ arc 22.994466 u and 22.989770 u, respectively.

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32. Calculate the energy released during the combination of four hydrogen atoms and forming a helium atom along with two positrons. Use the atomic masses given as follows:

$m\left({}_1H^1\right) = 1.007824u$, $m\left({}_2He^4\right) = 4.002604u$ and mass of each positrons = 0.000548 u.

33. Calculate the energy released in MeV during the reaction ${}_{3}^{7}Li + {}_{1}^{1}H \rightarrow 2\left[{}_{2}^{4}He\right]$ if the masses of ${}_{3}^{7}Li$, ${}_{1}^{1}H$ and ${}_2H_4He$ are 7.018, 1.008 and 4.004 amu respectively.
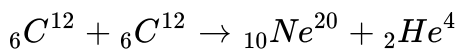
34. In a nuclear explosion, 180 MeV energy was released per fission and a total energy of 8×10^{13} joules was released. Calculate the mass of uranium used in the explosion.

35. Calculate the energy released in the given reaction:

$_6C^{12} + {}_6C^{12} \rightarrow {}_{10}Ne^{20} + {}_2He^4$

Given atomic masses are as follows:

$M_{He} = 4.002603u, M_{Ne} = 19.992439u,$

$M_c = 12.0000u$

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36. In a nuclear explosion, one kg uranium was used. Calculate the energy released during the explosion if mass defect involved in the fusion is 0.2%.

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37. When one atom of $_{92}U^{235}$ undergoes fission, 200 MeV energy is released. Calculate the amount of energy released using 0.5 grams of it.

38. Calculate the amount of $_{92}U^{235}$ required to release energy of 1 kWh. Given energy released during fission of one atom is 200 MeV.

Conceptual Questions

1. Nuclei above bismuth-209 are unstable irrespective of their neutron-proton ratio. Explain?

2. What is the fate of a free neutron?

3. Two nuclei have mass number in the ratio 1:2. What is the ratio of their nuclear densities?

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4. Why is the mass of a nucleus always less than the sum of the masses of its constituents-neutrons and protons?
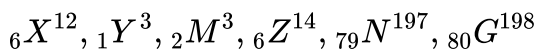
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5. Calculate the ratio of radii of two nuclei with mass numbers in ratio 8 : 27.

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6. Identify the pair of isotopes, isobars and isotones from the following:

$_6X^{12}, \, _1Y^3, \, _2M^3, \, _6Z^{14}, \, _{79}N^{197}, \, _{80}G^{198}$

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7. Isolated proton does not decay into neutron but an isolated neutron can decay into proton. Explain.

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8. Draw the curve showing the variation of binding energy per nucleon as a function of mass number A. Explain the stability of the nucleus from the curve .

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9. Why do all electrons emitted during β - decay not have the same energy ?

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10. Why is density of a nucleus much more than the atomic density?

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11. Why is nuclear density same for all nuclei?

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12. Determine the number of electrons, proton and neutrons in the nucleus in $_{11}Na^{22}$.

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13. The binding energies of two particles X and Y are 2.26 MeV/nucleon and 7.56 MeV/nucleon, respectively. Which of the following is more stable?

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14. Which is the most unstable elementary particle in an atom?

15. Nucleus contains protons and neutrons only but in beta decay, the electrons are emitted from the nucleus. Explain.

16. During alpha decay of a nucleus, how does the neutron to proton ratio change?

17. During beta decay of a nucleus, how does the neutrons to proton ratio change?

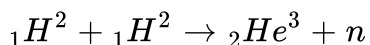**18.** A nucleus with mass number A =240 and BE$/$A = 7.6 Me V breaks into two fragments each of A =120 with BE/A =8.5 Me V .Calculate the released energy .

19. Calculate the energy in the given fusion reaction.

$$_1H^2 + {_1}H^2 \rightarrow {_2}He^3 + n$$

Given, B.E. of $_1H^2 = 2.23$ MeV and B.E. of $_2He^3 = 7.73$ MeV.

20. Why plutonium is not found in observable quantity in the universe?

21. Four nuclei of an element undergo fusion to form a heavier nucleus , with release of energy . Which of the two - the parent or the daughter nucleus - would have higher binding energy per nucleon ?

22. Is it possible for $_{92}U^{238}$ spontaneously to emit a proton? Given, atomic mass of $_{92}U^{238}$, $_{91}Pa^{237}$ and $_{1}H^{1}$ is 238.05079 u, 237.05115 u and 1.00783 u respectively.

23. Answer the following questions:

a) Are the equations of nuclear reactions 'balanced' in the sense a chemical equation (e.g., 2H2 + O2→ 2 H2O) is? If not, in what sense are they balanced on both sides?

b) If both the number of protons and the number of neutrons are conserved in each nuclear reaction, in what way is mass converted into

energy (or vice-versa) in a nuclear reaction?

c) A general impression exists that mass-energy interconversion takes place only in nuclear reaction and never in chemical reaction. This is strictly speaking, incorrect. Explain.

24. If both the numbers of protons and neutrons are conserved in each nuclear reaction, in what way is mass converted into energy (or vice versa) in a nuclear reaction?

25. Which among alpha and beta particles have higher ionising power and why?

26. Order of ionization power of α, β and γ rays is

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27. What is the difference between a beta particle and electron?

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28. How is reaction rate controlled in a nuclear reactor?

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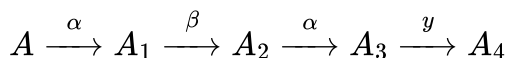**29.** What is the role of heavy water in a nuclear reactor?

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30. State the reason, why heavy water is generally used as a moderator in a nuclear reactor.

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31. A radiactive nucleus $'A'$ undergoes a series of decays according to the following scheme:

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{y} A_4$$

The mass number and atomic number A are 180 and 72 respectively. What are these number for A_4?

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Tough Tricky Problems

1. Find the speed of particle produced during the decay of $_{92}p^{235} \to {}_{90}q^{231}$. Assume that the energy shared by the daughter nucleus

is negligible. B.E./nucleon of $_{92}p^{235} = 7.81 MeV$.

B.E./nucleon of $_{90}Q^{231} = 7.834 MeV$

B.E./nucleon of α-particle = 7.02 MeV

Mass of α-particle $= 6.7 \times 10^{-27}$ kg

2. A Geiger counter is placed at a distance of 5 m from a γ radiation source. The half-life of γ radiation source is 40 minutes and the count rate recorded by the Geiger counter is $400s^{-1}$. If the distance between the source and the counter is changed, then the count rate recorded will be $10s^{-1}$ after 2 hours. Find the new distance between the source and the counter.

3. Calculate the total number of disintegration for a radioactive isotope in the twentieth hour which is measured from a time when activity was 2 Ci. Given that the half-life of the isotope is 20 h.

4. Nitrogen with mass number 13 and atomic number 7 decays to carbon having Z = 6.

(a) Write an equation for this decay.

(b) How much time it will take to convert the mixture of nitrogen 80% and carbon 20% to a mixture of nitrogen 20% and carbon 80%. The half-life for this decay is 30 minutes.

5. 2 g of pure CsCl gives 200 counts s^{-1}. Calculate the relative abundance of Cs^{137} in natural caesium, if the half-life of Cs^{137} is 30 years.

6. The element curium $._{96}^{248}Cm$ has a mean life of $10^{13}s$. Its primary decay modes are spontaneous fission and α-decay, the former with a probability

of 8% and the later with a probability of 92%, each fission releases

$200 MeV$ of energy. The masses involved in decay are as follows

$^{248}_{.96} Cm = 248.072220u,$

$^{244}_{.94} P_u = 244.064100u$ and $^4_{.2} He = 4.002603u.$ Calculate the power output from a sample of 10^{20} Cm atoms. $(1u = 931 MeV/c^2)$

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7. A star initially has 10^{40} deuterons. It produces energy via the process

$- (1)H^2 +_1 H^2 + \rightarrow_1 H^3 + p.$ and $\quad - (1)H^2 +_1 H^3 + \rightarrow_2 He^4 + n$

.If the average power radiated by the state is $10^{16}W$, the deuteron supply of the star is exhausted in a time of the order of .

The masses of the nuclei are as follows:

$M(H^2) = 2.014a\mu,$

$M(p) = 1.007a\mu, M(n) = 1.008a\mu, M(He^4) = 4.001a\mu.$

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8. A nuclear reactor generates power at 50% efficiency by fission of $_{92}^{235}U$ into two equal fragments of $_{46}^{116}U$ into two equal fragments of $_{46}^{116}Pd$ with the emission of two gamma rays of 5.2 MeV each and three neutrons. The average binding energies per particle of $_{92}^{235}U$ and $_{46}^{116}Pd$ are 7.2 MeV and 8.2MeV respectiveley. Calculate the energy released in one fission event. Also-estimate the amount to ^{235}U consumed per hour to produce 1600 megawatt power.

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9. A nucleus X, initially at rest , undergoes alpha dacay according to the equation ,

$$_-(92)^A X \rightarrow_Z^{228} Y + \alpha$$
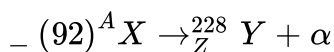
(a) Find the value of A and Z in the above process.

(b) The alpha particle produced in the above process is found to move in a circular track of radius $0.11m$ in a uniform magnetic field of 3 Tesla find the energy (in MeV) released during the process and the binding energy of the parent nucleus X

Given that : $m(Y) = 228.03u$, $m\left(_{-}(0)^1 n\right) = 1.0029u$.

$m\left(_{-}(2)^4 He\right) = 4.003u$, $m\left(_{-}(1)^1 H\right) = 1.008u$

Ncert File Solved Textbook Exercises

1. (a) Two stable isotope of $._3 Li^6$ and $._3 Li^7$ have respective abundances of 7.5 % and 92.5 % . These isotopes have masses 6.01512 and 7.01600 u respectively. Find the atomic weight of lithium.

(b) Boron has two stable isotopes $._5 B^{10}$ and $._5 B^{11}$. Their respective masses are 10.01294 u and 11.00931 u, and the atomic weight of boron is 10.81 u. Find the abundances of $._5 B^{10}$ and $._5 B^{11}$.

2. The three stable isotopes of neon $._{10} Ne^{20}$, $._{10} Ne^{21}$ and $._{10} Ne^{22}$ have respective abundances of 90.51 % , 0.27 % and 9.22 % . The atomic

masses of the three isotopes are $19.99u$, $20.99u$ and $21.99u$ respectively.

Obtain the average atomic mass of neon.

3. Obtain the binding energy (in MeV) of a nitrogen nucleus $\left(^{14}_{7}N\right)$, given

$m\left(^{14}_{7}N\right)$

$= 14.00307 \quad u$

4. Obtain the binding energy of the nuclei $_{.26}Fe^{56}$ and $_{.83}Bi^{209}$ in units

of MeV from the following data: $m\left(_{.26}Fe^{56}\right) = 55.934939a.\,m.\,u.$,

$m = \left(_{.83}Bi^{209}\right) = 208.980388amu.$ Which nucleus has greater binding

energy per nucleon? Take $1a.\,m.\,u = 931.5MeV$

5. A given coin has a mass of 3.0 g. Calculate the nuclear energy that would be required to separated all the neutrons and protons form each other. for simplicity, assume that the coin is entirely made of $_{.29}Cu^{63}$ atoms (of mass 62.92960 u).

6. Write nuclear reaction equation for

(i) α decay of $_{.88}Ra^{226}$ (ii) α decay of $_{.94}Pu^{242}$ (iii) β^- decay of $_{.15}P^{32}$

(iv) β^- decay of $_{.83}Bi^{210}$ (v) β^+ decay of $_{.6}C^{11}$ (vi) β^+ decay of $_{.43}Tc^{97}$

(vii) Electron capture of $_{.54}Xe^{120}$.

7. A radioactive isotope has a life of T years. How long will it take the activity to reduce to (a) 3.125% $(b)1\%$ of its original activity?

8. The normal activity of living carbon -containing matter is found to be about 15 decay per minute for every gram of carbon. This activity arises form the small proportion of radioactive $._6 C^{14}$ present with the ordinary $._6 C^{12}$ isotope. When the organism is dead, its interaction with the atmosphere which maintains the above equilibrium activity, ceases and its activity begins to drop. from the known half life (=5730years) of $._6 C^{14}$, and the measured activity, the age of the specimen can be approximately estimated. This is the principle of $._6 C^{14}$ dating used in archaeology. Suppose a specimen from Mohenjo - daro gives an activity of 9 decays per minute per gram of carbon. Estimate the approximate age of the Indus Valley Civilization.

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9. Obtain the amount of $._{60} Co$ necessary to provide a radioactive source of $8.0Ci$ strength. The half-life of $._{60} Co$ is 5.3 years?

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10. The half life of $_{38}^{90}Sr$ is 28 years. The disintegration rate of 15 mg of this isotope is of the order of

11. Obtain approx. the ratio of the nuclear radii of the gold isotope $_{79}Au^{197}$ and silver isotope $_{47}Ag^{107}$.

12. Find the Q value and the kinetic energy of emitted α particle in the α decay of

(a) $_{88}Ra^{226}$ (b) $_{86}Rn^{220}$.

Given $m\left(_{88}Ra^{226}\right) = 226.02540u$, $m\left(_{86}Rn^{222}\right) = 222.01750u$

(b) $m\left(_{86}Rn^{220}\right) = 220.01137u$, $m\left(_{84}Po^{216}\right) = 216.00189u$ and

$m_{\alpha} = 4.00260u$.

13. The radionuclide $._6 C^{11}$ decays according to $._6 C^{11} \rightarrow ._5 B^{11} + e^+ + v$: half life =20.3min. The maximum energy of the emitted positron is $0.960 MeV$. Given the mass values

$$m\left(._6 C^{11}\right) = 11.011434u, \; m\left(._6 B^{11}\right) = 11.009305u$$

Calculate Q and compare it with maximum energy of positron emitted.

14. The nucleus $.^{23} Ne$ deacays by β-emission into the nucleus $.^{23} Na$. Write down the β-decay equation and determine the maximum kinetic energy of the electrons emitted. Given, $\left(m\left(._{11}^{23} Ne\right) = 22.994466 amu \right.$ and $m\left(._{11}^{23} Na\right) = 22.989770 amu$. Ignore the mass of antineuttino $(\bar{v})$.

15. The Q value of a nuclear reaction

A+b=C+d is defined by $Q = [m_A + m_b - m_C - m_d]c^2$ where the masses refer to the respective nuclei. Determine form the given data the Q value

of the following reactions and state whether the reactions are exothermic of endothermic.

(i) $\cdot_1 H^1 + \cdot_1 H^3 \rightarrow \cdot_1 H^2 + \cdot_1 H^2$

(ii) $\cdot_6 C^{12} + \cdot_6 C^{12} \rightarrow \cdot_{10} Ne^{20} + \cdot_2 He^4$
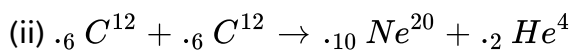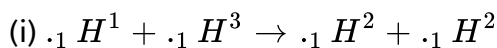
Atomic masses are given to be

$m\left(\cdot_1 H^2\right) = 2.014102u, \ m\left(\cdot_1 H^3\right) = 3.016049u, \ m\left(\cdot_6 C^{12}\right) = 12.000000u,$

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16. Suppose, we think of fission of a $\cdot_{26} Fe^{56}$ nucleus into two equal fragments $\cdot_{13} Al^{28}$. Is the fission energetically possible? Argue by working out Q of the process. Given

$m\left(\cdot_{26} Fe^{56}\right) = 55.93494u, \ m\left(\cdot_{13} Al^{28}\right) = 27.98191u.$

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17. The fission properties of $\cdot_{84} Pu^{239}$ are very similar to those of $\cdot_{92} U^{235}$. The average energy released per fission is $180 MeV$. How much energy in MeV is released if all the atoms in 1kg of pure $\cdot_{94} Pu^{239}$ undergo fission.

18. A 1000 MW fission reactor consumes half of its fuel in 5.00y. How much $_{.92}U^{235}$ did it contain initially? Assume that the reactor operates 80% of the time and that all the energy generated arises form the fission of $_{.92}U^{235}$ and that this nuclide is consumed by the fission process.

19. How long can an electric lamp of 100W be kept glowing by fusion of 2.0 kg of deuterium? The fusion reaction can be taken as

$$_{.1}H^2 + {}_{.1}H^2 \to {}_{.1}H^3 + n + 3.17 MeV$$

20. Calculate the height of potential barrier for a head on collision of two deuterons. The effective radius of deuteron can be taken to be 2fm. Note

that height of potential barrier is given by the Coulomb repulsion between two deuterons when they just touch each other.

21. from the relation $R = R_0 A^{1/3}$, where R_0 is a constant and A is the mass number of a nucleus, show that the nuclear matter density is nearly constant (i.e., independent of A).

22. for the β^+ (positron) emission from a nucleus, there is another competing process known as electron capture. Electron from an inner orbit (say K shell) is captured by the nucleus and neutrino is emitted. Show that if β^+ emission is energetically allowed, electron capture is necessarily allowed but not vice -versa.

1. In a periodic table, the average atomic mass of magnesium is given as $24.312u$. The average value is based on their relative natural abundance on earth. The three isotopes and their masses are $._{12}Mg^{24}(23.98504u)$, $._{12}Mg^{25}(24.98584)$ and $._{12}Mg^{26}(25.98259u)$. The natural abundance of $._{12}Mg^{24}$ is 78.99 % by mass. Calculate the abundances of the other two isotopes.

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2. The neutron separation energy is defined to be the energy required to remove a neutron form nucleus. Obtain the neutron separation energy of the nuclei $._{20}Ca^{41}$ and $._{13}Al^{27}$ from the following data :

$m\left(._{20}Ca^{40}\right) = 39.962591u$ and $m\left(._{20}Ca^{41}\right) = 40.962278u$

$m\left(._{13}Al^{26}\right) = 25.986895u$ and $m\left(._{13}Al^{27}\right) = 26.981541u$

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3. A source contains two phosphorus radionuclides $_{.15}P^{35}\,(T_{1/2}=14.3\text{days})$ and $_{.15}P^{33}\,(T_{1/2}=25.3\text{days})$. Initially, $10\,\%$ of the decays come from $_{.15}P^{35}$. How long one must wait until $90\,\%$ do so?

4. Under certain circumstances, a nucleus can decay by emitting a particle more massive than an α-particle. Consider the following decay processes:

$_{.88}Ra^{223}\rightarrow{}_{.82}Pb^{209}+{}_{.6}C^{14},\,{}_{.88}Ra^{223}\rightarrow{}_{.86}Rn^{219}+{}_{.2}He^{4}$
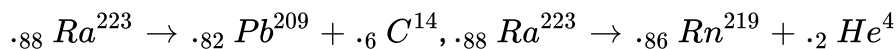
(a) Calculate the Q-values for these decays and determine that both are energetically allowed.

5. Consider the fission $_{.92}U^{238}$ by fast neutrons. In one fission event, no neutrons are emitted and the final stable and products, after the beta decay of the primary fragments are $_{.58}Ce^{140}$ and $_{.44}Ru^{99}$. Calculate Q for
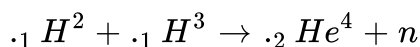
this fission process, The relevant atomic and particle masses are:

$$m\left(._{92} U^{238}\right) = 238.05079u, \ m\left(._{58} Ce^{140}\right) = 139.90543u, \ m\left(._{34} Ru^{99}\right) = 98.$$

6. Consider the so called D-T reaction (deuterium-tritium fusion)

$$._1 H^2 + ._1 H^3 \rightarrow ._2 He^4 + n$$

Calculate the energy released in MeV in this reaction from the data

$$m\left(._1 H^2\right) = 2.014102u, \ m\left(._1 H^3\right) = 3.016049u$$

(b) Consider the radius of both deuterium and tritium to be approximately 2.0fm. what is the kinetic energy needed to overcome the Coulomb repulsion between the two nuclei? To what temperature must the gases the be heated to initiate the reaction?

7. Obtain the maximum kinetic energy of β-particles, and the radiation frequencies of γ decays in the decay scheme shown in Fig. 14.6. You are

given that $m(.^{198}\,Au) = 197.968233u$, $m(.^{198}\,Hg) = 197.966760u$

$^{198}_{79}Au$

β_1^-

β_2^-

1.088Mev

γ_1

γ_3

0.412Mev

γ_2

0

$^{198}_{80}Hg$
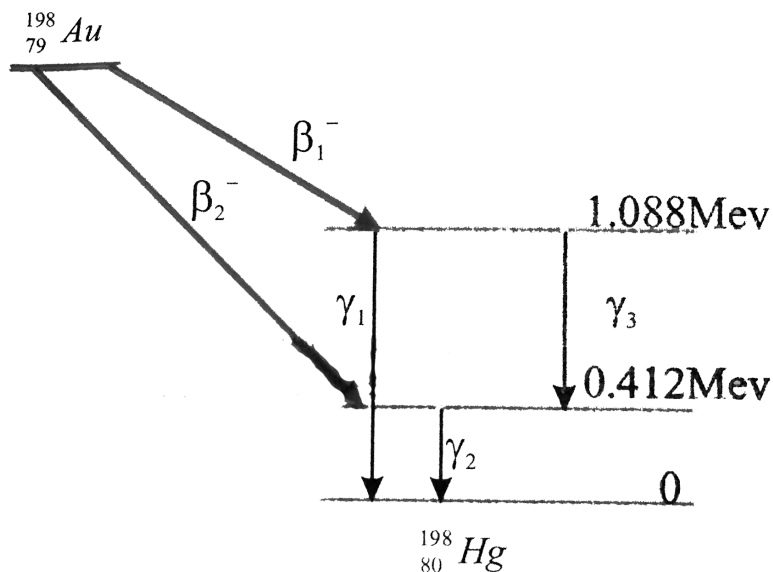
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8. Calculate and compare the energy released by (a) fusion of 1.0kg of hydrogen deep within the sun, and (b) the fission of 1.0kg of U^{235} in a fission reactor.

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9. Suppose India has a target of producing by $2020AD$, $200,000MW$ of electric power, ten percent of which was to be obtained from nuclear power plants. Suppose we are given that, on an avedrage, the efficiency of utilization(i.e conversion to electric energy) of thermal energy produced in a reactor was 25%. How much amount of fissionable uranium would our country need per year by 2020? Take the heat energy per fission of $.^{235}U$ to be about $200MeV$.

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1. He_2^3 and He_1^3 nuclei have the same mass number. Do they have the same binding energy ?

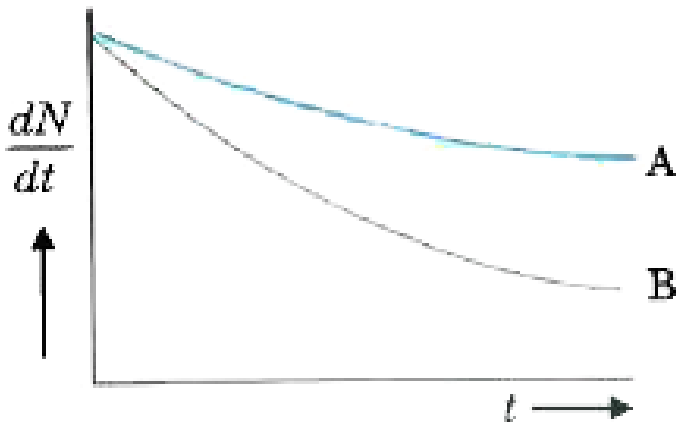> ▶ Watch Video Solution

2. Draw a graph showing the variation of decay rate with number of active nuclei.

3. Which sample, A or B, shown in the following figure has shorter mean life?

4. Which one of the following cannot emit radiation and why ? Excited nucleus excited electron.

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5. In pair annihilation an electron and a position destroy each other to produce gamma radiations . How is the momentum conserved ?

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Ncert File Solved Ncert Exemplar Problems Subjective Questions Short Answer Type Questions

1. Why do stable nuclei never have more protons than neutrons ?

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2. Consider a radioactive nucleus A which decays to a stable nucleus C through the following sequence

$$A \rightarrow B \rightarrow C$$

Here B is an intermediate nuclei which is also radioactive. Considering that there are N_0 atoms of A initially , plot the praph showing the variation of number of atoms of A and B versus time.

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3. A piece of wood form the ruins of an ancient building was found to have a C^{14} activity of 12 disintegrations per minute per gram of its carbon content. The C^{14} activity of the living wood is 16 disintegrations/minute/gram. How long ago did the trees, from which the wooden sample came, die? Given half-life of C^{14} is 5760 years.

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4. Are the nucleons fundamental particles or do they consist of still smaller perts One way to find out is to probe a nucleon just as Rutherford probed and atom . What should be the kinetic energy of an electron for it to be able to probe a nucleon? Assume the diameter of a nucleon to be approximately $10^{-15}m$.

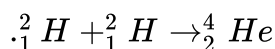▶ **Watch Video Solution**

5. A nuclide 1 is said to be the mirror isobar of nuclide 2 if $Z_1 = N_2$ and $Z_2 = N_1$. (a) What nuclide is a mirror isobar of $._{11}^{23} Na$? (b) Which nuclide out of the two mirror isobars has greater binding energy and why?

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High Order Thinking Skills Advanced Level

1. It is proposed to use the nuclear fusion reaction,

$._1^2 H +_1^2 H \rightarrow_2^4 He$

in a nuclear reactor $200MW$ rating. If the energy from the above reaction is used with a 25 per cent efficiency in the reactor, how many grams of deuterium fuel will be needed per day?(The masses of $._1^2H$ and $._2^4He$ are 2.0141 atomic mass units and 4.0026 atomic mass units respectively.)

2. Following fusion reaction is to be used for the production of power.

$$_1H^2 + _1H^2 \rightarrow _1H^3 + _1H^1$$
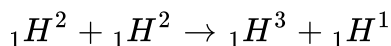
Calculate requirem ent of mass of deuterium per day if power is produced at a rate of 10^9 W. Assume that the above process is used w ith efficiency of 50%.

$m\left(_1H^2\right) = 2.01458$ amu

$m\left(_1H^3\right) = 3.01605$ amu

$m\left(_1H^1\right) = 1.00728$ amu

1 amu $= 931MeV/c^2$.
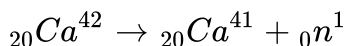
3. A stream of neutrons is moving with a velocity of 4×10^3 m/s. What fraction of neutrons will decay before they travel a distance of 20 m. Given half-life of neutrons = 800 seconds and mass of neutron = 0.67×10^{-27} kg.

4. Consider the following reaction:

$$_{20}Ca^{42} \rightarrow {}_{20}Ca^{41} + {}_0n^1$$

Calculate the energy E required to remove this neutron from $_{20}Ca^{42}$.

Further, energy required to remove a proton from $_{20}Ca^{42}$ is E'

What would you suggest whether E' would be less than or greater than E and why?

Mass of $_{20}Ca^{42} = 41.9586$

Mass of $_{20}Ca^{41} = 40.9622$ u

Mass of neutron =1.0072 u

5. Calculate the number of electrons, protons and neutrons present in 24 grams of $_{12}Mg^{24}$ and $_{12}Mg^{26}$.

6. In the nuclear fission of $_{92}U^{235}$, 200 MeV of energy is released per fission. Calculate the output power of the reactor if 3 kg of fuel is used in 40 days.

7. The energy released due to fission of one atom of a radioactive substance is 170 MeV. Calculate the number of atoms disintegrated per second in the reactor if the power obtained from the rector is 2,000 kW. Also, calculate the decay in mass in one hour.

8. Thorium $_{90}th^{228}$ is a radioactive substance and decay to a daughter nucleus. This daughter nucleus is also radioactive and further decays itself. The process continues till the formation of $_{83}Bi^{212}$. Find the total number of a particles and P particles produced in these decays.

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9. The average life of a radioactive sample is 100 millisecond. A charged capacitor having capacitance 200 μF is connected across a resistance R. For what value of R, the ratio of charge on capacitor to the activity of the sample remains constant with time or independent of time.

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Revision Exercises Very Short Answer Questions

1. Two nuclie have mass numbers in the ratio $1:2$. What is the ration of their nuclear densities ?

2. Two nuclei have mass number in the ratio 1:8. What is the ratio of their

nuclear radii?

3. Why is a $._2^4 He$ nucleus more stable than a $._3^4 Li$ nucles ?

4. Why is density of a nucleus much more than the atomic density?

5. Draw the plot of binding energy per nucleon as a function of mass

number and write two important conclusion obtained from the graph.

6. MASS DEFECT

7. Binding energy of a nucleus is.

8. What is Mass defect, binding energy and binding energy per nucleon?

9. How many electrons, protons and neutrons are there in 16 g of $^{8}o_{16}$?

10. What is the value of binding energy per nucleon in case of $_{92}U^{238}$?

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11. Who discovered radioactivity?

> ▶ **Watch Video Solution**

12. Why tritium and plutonium are not found in observable quantities in nature?

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13. Amongst α, β and $\gamma-$ particles, $\alpha-$ particle has maximum penetrating power.

The $\alpha-$ particle is heavier than β and $\gamma-$ particle.

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14. What do you mean by half-life of a radioactive substance ?

15. Write the relation between Half-Life and Mean-Life of radio active element.

16. Define the activity of a radionuclide. Write its SI unit. Give a plot of the activity of a radioactive species versus time.

17. 1 Decay per second are equivalent to what unit of radioactivity?

18. By which process does a cobalt nucleus change into a nickel nucleus?

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19. एक रेडियोसक्रिय पदार्थ की सक्रियता 1 रदरफोर्ड हैं पदार्थ में प्रति सेकण्ड विघटनों की संख्या है-

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20. Calculate the energy equivalent of 1 a.m.u. in MeV

▶ **Watch Video Solution**

21. Write the relation between volume and the mass number of an atomic nucleus.

▶ **Watch Video Solution**

22. What are isotopes? Give one example.

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23. What are isobars? Give examples.

▶ Watch Video Solution

24. What are isotones? Give examples.

▶ Watch Video Solution

25. In both β^{-1} and β^{+} decay processes, the mass number of a nucleus remains same, whereas the atomic number Z increases by one in β^{-} decay and decreases by one in β^{+} decay. Explain by giving reason.

▶ Watch Video Solution

26. Why is it found experimentally difficult to detect neutrinos in nuclear β-decay?

▶ Watch Video Solution

27. Explain α- decay ?

▶ Watch Video Solution

28. Why α particles have high ionising power than β rays?

▶ Watch Video Solution

29. How do the mass number and atomic number change in α -decay? A nucleus X becomes nucleus Y as a result of α-decay. Represent it by an equation.

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30. What percentage of a radioactive substance will left undecayed after four half-life periods?

▶ View Text Solution

31. A radioactive nucleus decays by emitting one alpha and two beta particles, the daughter nucleus is ..... Of the parent.

▶ Watch Video Solution

32. Why control rods are made up of cadmium?

▶ Watch Video Solution

33. Why nuclear fusion is very difficult to carry out?

▶ View Text Solution

34. Why nuclear fusion is also known as thermonuclear reaction?

35. Write the relation between average life and decay constant of a radioactive atom.

36. When a β^- particle is emitted from a nucleus, the neutrons-proton ratio:

37. The curve representing the energy spectrum of β-particles is

38. β^+ तथा β^- क्षय क्रिया समझाइए |

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39. What is nuclear fission ? Given an example to illustrate it.

▶ **Watch Video Solution**

40. What do you mean by nuclear fusion ?

▶ **Watch Video Solution**

41. नाभिकीय श्रृंखला अभिक्रिया में न्यूट्रॉन गुणन कारक से क्या तात्पर्य हैं?

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42. What is meant by chain reaction ?

43. What happens when neutron reproduction factor is greater than one?

44. What is the role o f coolant in nuclear reactors?

45. What do you mean by nuclear holocaust?

46. In proton-proton cycle, what is the approximate energy released?

47. Four nuclei of an elements undergo fusion to form a heavier nucles, with release of energy. Which of the two - the parent or the daughter nucleus - would have higher binding energy per nucleon ?

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1. If N_0 is the original mass of the substance of half - life period $t_{1/2} = 5year$ then the amount of substance left after 15 year is

A. $\dfrac{N_0}{8}$

B. $\dfrac{N_0}{16}$

C. $\dfrac{N_0}{2}$

D. $\dfrac{N_0}{4}$

Answer: A

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2. In nuclear reaction $._4 Be^9 + ._2 He^4 \rightarrow ._6 C^{12} + X$, X will be

A. 16

B. 12

C. 10

D. 14

Answer: B

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3. Which of the following is used as a moderator in nuclear reactors ?

A. Uranium

B. Heavy water

C. Cadmium

D. Plutonium

Answer: B

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4. In nuclear transformation

$$_aX^b + _0n^1 \rightarrow _3Li^7 + _2He^4$$
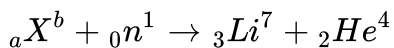
Which one is the nucleus of X?

A. $_5B^{10}$

B. $_5B^9$

C. $_4Be^{11}$

D. $_6C^{12}$

Answer: A

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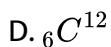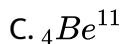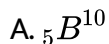
5. Nature of electric force between two protons is:

A. Attractive

B. Neutral

C. Repulsive

D. None of the above

Answer: C

▶ View Text Solution

6. Who discovered the nucleus?

A. Thomson

B. Bohr

C. Rutherford

D. de Broglie

Answer: C

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7. A radioactive element emits 2 α-particles and 3 β-particles . The values of atomic number (Z) and mass number (A) of the new element will be

    A. (A+5),(Z-1)

    B. (A-5),(Z+1)

    C. (A-8),(Z-1)

    D. (A-8),(Z+1)

Answer: C

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8. A nucleus $._n^m X$ emits one $\alpha-$ particle and two $\beta-$ particles. The resulting nucleus is

    A. $_{n-2}X^{n-1}$

    B. $_{n-1}X^{m-4}$

C. $_{n-1}X^{m-4}$

D. $_nX^{m-4}$

Answer: D

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1. ....is a process in which a heavy nucleus breaks into two middle-weight nuclei.

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2. The average life of a radioactive element is .... of the decay constant.

▶ Watch Video Solution

3. The energy released per unit mass of the fuel in fusion is .... than that produced in fission.

> ▶ Watch Video Solution

4. $_0n^1 + _{92}U^{235} \rightarrow _{92}U^{236} \rightarrow$ .... $+ _{36}Kr^{89} + 3_0n^1$
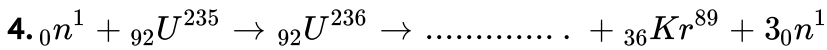
> ▶ Watch Video Solution

5. 1 Rutherford = ... disintegrations/sec

> ▶ Watch Video Solution

6. PACKING FRACTION

> ▶ Watch Video Solution

7. Heavy nuclei are having .... protons than neutrons.

8. Radioactivity is the property due to which a heavy nucleus can decay.................without the help of an external agent.

9. Isotopes are the atoms of same element having......... mass number and ....atomic number.

10. Isotones contain same number of ....

1. बन्धन ऊर्जा वक्र खींचिए |

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2. नाभिक का द्रव्यमान सदैव उनके घटक न्यूट्रॉनों और प्रोट्रॉनों के द्रव्यमान के योग से कम होता है। समझाइए।

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3. Briefly describe the working of a nuclear reactor

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4. ऐल्फा क्षय , बीटा क्षय तथा गामा क्षय को विस्तार से समझाइयें ।

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5. How many α and β-particles are emitted when U-238 changes to Pb-206 due to radioactivity. Atomic numbers of U-238 and Pb-206 are 92 and 82 respectively.

6. State the law of radioactivity and hence, show that $N = N_0 e^{-\lambda t}$.

7. (a) Draw a graph showing the variation of binding energy per nucleon (BE/A) vs mass number A for the nuclei in $20 \leq A \leq 170$.

(b) A nucleus of mass number 240 and having binding energy/nucleon 7.6 MeV splits into two fragments Y, Z of mass numbers 110 and 130 respectively. If the binding energy/nucleon of Y, Z is equal to 8.5 MeV each, calculate the energy released in the nuclear reaction

8. State the law of redioactive decay. Plot a graph showing the number (N) of undecayed nuclei as a functin of time (t) for a given radioactive sample having half life $T_{1/2}$
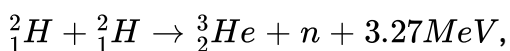
Depict in the plot the number of undecayed nuclei at

(i) $t = 3T_{1/2}$ and (ii) $t = 5T_{1/2}$.

9. In a typical unclear reaction, e.g.

$_1^2H + _1^2H \rightarrow _2^3He + n + 3.27 MeV,$

although number of nucleons is conserved is conserved, yet energy is released. How ? Explain.

(b) Show that nuclear density in a given nucleus is independent of mass number A.

10. The half life of a radioactive substance is 20s. Calculate (i) the decay constant, and (ii) time take by the sample to decay by $7/8th$ of its initial value

11. What is meant by activity of a radioactive substance? Write its SI unit.

12. A radiactive nucleus $'A'$ undergoes a series of decays according to the following scheme:

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{y} A_4$$
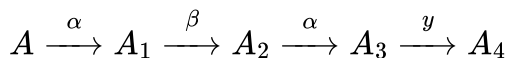
The mass number and atomic number A are 180 and 72 respectively. What are these number for A_4?

13. (a) What are isotones?

(b) $A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3$
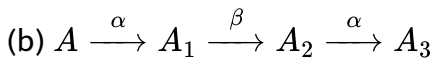
The mass number and atomic number of A are 180 and 72 respectively.

What are these numbers for A_3 ?

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14. Draw a graph between potential energy of a pair of nucleons and

separation between them. Also write its main features.

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15. The voltage applied across the cathode and anode of an X-ray

generating machine is 50,000 V. Determine the shortest wavelength of

the X-ray emitted, given ,$h = 6.62 \times 10^{-34}$ Js.

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16. नाभिकीय संलयन और नाभिकीय विखण्डन के बीच विभेद कीजिए |

17. (a) Distinguish between isotopes and isobars, giving one example for each. Write one example to justify your answer.

18. Draw the curve showing the variation of binding energy per nucleon as a function of mass number A. Explain the stability of the nucleus from the curve .

19. What is the role of controlling rods in a nuclear reactor ?

20. यूरेनियम के परमाणु के विखण्डन से कितनी ऊर्जा होती है?

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21. नाभिकीय विखण्डन की परिभाषा लिखिए।

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Revision Exercises Long Answer Questions

1. नाभिक की बंधन ऊर्जा से आप क्या समझते हैं? नाभिकों की प्रति न्यूक्लिऑन बंधन ऊर्जा तथा द्रव्यमान संख्या की बीच ग्राफ खींचिए। इस ग्राफ को क्या कहते हैं इस ग्राफ से प्राप्त महत्वपूर्ण निष्कर्षों को लिखिए।

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2. Define 'half life' , 'decay constant and 'mean life'of a radioactive element and write the relation connecting them.

3. (a) State the laws of radioactive decay and deduce the relation:

$$N = N_0 e^{-\lambda t}$$

$$N = N_0 e^{-\lambda t}$$

Where the symbols have their usual meaning.

(b) (i) Write symbolically the process expressing the β^+ decay of $_{11}Na^{22}$. Also write the basic nuclear process underlying this decay.

(ii) Is the nucleus formed in the decay of the nucleus $_{11}Na^{22}$ an isotope or isobar?

4. रेडियोऐक्टिव क्षय से क्या तात्पर्य है ? रेडियोऐक्टिव विघटन का नियम लिखिए तथा दर्शाइए की रेडियोऐक्टिव विघटन चरघातांकी होता है |

5. न्यूक्लियर रिएक्टर के विभिन्न भागो को बताइये! समझाइए की नाभिकीय ऊर्जा की वैधुत ऊर्जा में किस प्रकार प्राप्त किया जाता है?

6. नाभिकीय विखण्डन से क्या तात्पर्य है? विखण्डन क्रिया स्वयं श्रृंखलाबद्ध क्यों नहीं होती? श्रृंखलाबद्ध अभिक्रिया प्राप्त करने के लिए क्या करते हैं?

7. Uranium U_{92}^{235} on bombardment with slow neutrons produces

Revision Exercises Numerical Problems

1. Find the ratio of nuclear radii of two elements $_{12}Mg^{24}$ and $_1H^3$

2. Calculate the amount of energy released during the α-decay of

$$_{92}^{238}U \rightarrow _{90}^{234}Th + _2^4He$$
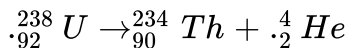
Given: atomic mass of $_{92}^{238}U = 238.05079u$, atomic mass of

$_{90}^{234}Th = 234.04363u$,
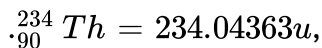
atomic mass $_2^4He = 4.00260u$, $1u = 931.5MeV/c^2$. Is this decay

spontaneous?Give reason.

3. The half life of $_{92}^{238}U$ undergoing α-decay is 4.5×10^9 years. The

activity of 1 g sample of $_{92}^{238}U$ is

4. Define the term 'decay constant' of a radioactive sample. The of disintergration of a given radioactive nucleus is 10000 disintegrations/s and 5,000 disintegration/s after 20 hr. and 30 hr. respectively from start. Calculate the half life and initial number of nuclei at t = 0.

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5. Calculate the energy equivalent of 2 g of a substance.

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6. A radioactive substance has a half-life period of 40 days. Calculate the time taken for 3/4th of original atoms to disintegrate.

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7. Tritium has a half-life of 12.5 years. What fraction of the sample will remain undecayed after 50 years?

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8. Find the activity of 1 g sample of $_{84}Po^{210}$. The half-life of $_{84}Po^{210}$ is 138 days.

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9. Find the amount of $_{92}U^{238}$ required to produce a-particles of 20 millicurie strength. The half-life of $_{92}U^{238}$ is 4.5×10^9 years.

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10. Find the kinetic energy of emitted a-particles in the following nuclear reaction:

$$_{94}Pu^{238} \rightarrow {}_{92}U^{234} + {}_2He^4$$
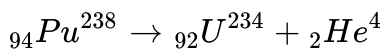
$$m\left(Pu^{238}\right) = 238.04954 \text{ amu}$$

$$m\left(U^{234}\right) = 234.04096 \text{ amu}$$

$$m\left({}_2He^4\right) = 4.002603 \text{ amu}$$

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11. The mass defect is 0.5% in a nuclear fusion reaction. Find the energy released in the fusion of 5 kg mass.

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12. Find the number of fissions required to produce a power of 2,000 W, if 200 MeV of energy is produced in the fission of single uranium nucleus.

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13. Two radioactive substances X and Y initially contain an equal number of atoms. Their half-lives are 1 hour and 2 hours respectively. Then the ratio of their rates of disintergration after two hours is

14. (a) Write the relation between half-life and average life of a radioactive nucleus.

(6) In a given sample two isotopes A and B are initially present in the ratio of 1 :2. Their half-lives are 60 years and 30 years respectively. How long will it take so that the sample has these isotopes in the ratio of 2 : 1?

15. Find the activity of 1.00 mg of radon Rn^{222}, whose atomic mass is 222 u, given that half-life of radon is 3.8 days

16. Calculate the energy in fusion reaction:

$_1H^2 + {_1}H^2 \rightarrow {_2}He^3 + {_0}n^1,$ where B.E. Of $_1H^2 = 2.23\text{MeV}$ and $_2He^3 = 7.73$ MeV.
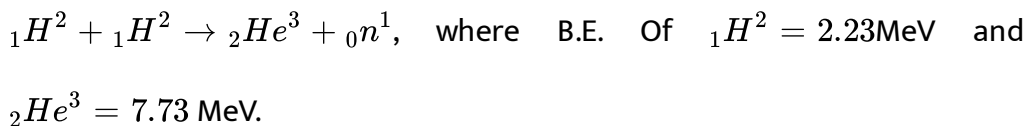
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17. A radioactive sample has a half-life of 4 years. Calculate the time in which the activity will be reduced to 25%.

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18. In how many years 1 g of pure radium will be reduced to 1 milligram? The half-life of radium is 1,500 years.

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Competition File Objective Type Questions Multiple Choice Questions

1. ऐल्फा, बीटा-कणों तथा गामा-किरणों को वेधन - क्षमता के घटते क्रम में लिखिए।

A. β, γ, α

B. α, β, γ

C. γ, β, α

D. β, α, γ

Answer: B

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2. On decay of $_{92}U^{238}$ to a stable nucleus $_{82}Pb^{206}$, the number of α and β particles emitted ar

A. 9,6

B. 8,6

C. 7,9

D. 10,6

Answer: B

---

3. The atomic masses of deuteron, helium, neutron are 2.014 amu, 3.017 amu and 1.008 amu respectively. On fusion of 0.5 kg of deuterium, $_1H^2 + {}_1H^2 \rightarrow {}_2He^3 + {}_0n^1$, the total energy released is

A. 6.72×10^{36} J

B. 7.72×10^{26} J

C. 6.72×10^{13} J

D. 8.72×10^{26} J

Answer: C

4. Let two radioactive substances have half-lives of 15 hours and 20 hours. At a given instant, the ratio of amount of radioactive substance is 2:1. The ratio of the quantities of the substances after 60 hours will be

A. 2

B. 1

C. 3

D. 4

Answer: B

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5. The radioactivity of a sample is R_1 at a time T_1 and R_2 at time T_2. If the half-life of the specimen is T, the number of atoms that have disintegrated in the time $(T_2 - T_1)$ is proporational to

A. $A_1 t_2 - A_2 t_1$

B. $(A_1 - A_2)T$

C. $(A_1 - A_2)^{-1}$

D. $A_1T - A_2T^2$

Answer: B

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6. For a radioactive sample, $\dfrac{15}{16}$ th part decays in 20 minutes. The half-life of the sample is

A. 4 minutes

B. 5 minutes

C. 6 minutes

D. 7 minutes

Answer: B

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7. Inside the core of nuclear fusion reactor, eventually the gas changes to plasma. It is due to

    A. strong coulomb forces acting between deuterons

    B. strong magnetic forces acting between protons

    C. the high temperature

    D. attractive coulomb forces between deuterons and electrons

Answer: C

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8. If 20% of a radioactive sample decays in 10 days, then the amount of substance left after 20 days will be approximately

    A. 0.6

    B. 0.61

C. 0.63

D. 0.7

Answer: C

9. A fraction f_1 of a radioactive sample decays in one mean life, and a fraction f_2 decays in one half life. Then

A. $X_1 < X_2$

B. $X_1 > X_2$

C. $X_1 \geq X_2$

D. $X_2 = 5.44X_1$

Answer: B

10. Which of the following is correct?

A. $_2He^4$ and $_2He^3$ have same binding energy.

B. An isolated proton can change into a neutron.

C. The energy distribution of β -rays is discrete.

D. An isolated neutron can change into a proton

Answer: D

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11. In a nuclear decay

$$_ZX^A \rightarrow _{z-1}M^{A-4} \rightarrow _{z-2}N^{A-4}$$

the particles emitted are in sequence:

A. β^+, β^-, α

B. β^+, α, β^-

C. α, β^-, β^+

D. β^-, α, β^+

Answer: B

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12. The graph showing the variation of decay rate with number of nuclei is:

A.

B.

C.

D.
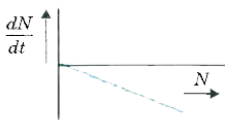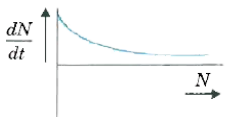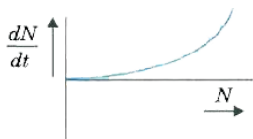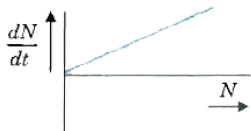
Answer: A

13. The number of protons and neutrons left in $_{92}U^{238}$ after emission of an a-particle are

A. 92, 146

B. 90, 144

C. 90, 234

D. 92, 144

Answer: B

14. A radioactive sample X has thrice the number of nuclei and activity one-third as compared to other radioactive sample Y. The ratio of half-lives of X and Y is

A. 6

B. 9

C. 12

D. 16

Answer: B

15. Two radioactive nuclei have same number of nuclei initially and decay constants as 5λ. And 4λ respectively. The ratio of number of nuclei will be $\dfrac{1}{e^2}$ after time:

A. $\dfrac{2}{\lambda}$

B. $\dfrac{3}{\lambda}$

C. $\dfrac{4}{\lambda}$

D. $\dfrac{5}{\lambda}$

Answer: A

---

16. The mass (m) and volume (V) for a heavy nucleus are related as

A. $m \propto V^{\frac{1}{2}}$

B. $m \propto \dfrac{1}{V}$

C. $m \propto V$

D. $m \propto \dfrac{1}{\sqrt{V}}$

Answer: C

---

17. The half-life of a radioactive sample A is same as the mean life of sample B. The number of atoms present initially in both the samples is same.

A. After 10 days, the number of atoms is same in A and B.

B. A decays at a faster rate than B.

C. A and B decay at same rate.

D. The decay rate of B is greater than A.

Answer: D

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18. $Au^{196} \rightarrow A^X + \beta^-$ antineutrino A and X are

A. Hg and 199, respectively

B. Hg and 198, respectively

C. Rn and 198, respectively

D. Pb and 199, respectively

Answer: B

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19. A radioactive sample has a half-life of 20 years. The time at which the activity of the sample will reduce to 10% of its initial value is

    A. 75 y

    B. 85 y

    C. 66 y

    D. 45 y

Answer: C

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20. A nucleus with atomic number Z (Z = 92) emits the following particles in a sequence $\alpha, \beta^-, \alpha, \alpha, \beta^-, \beta^+, \alpha, \beta^-, \alpha, \beta^+$. The atomic number of the resulting nucleus is

    A. 80

B. 81

C. 82

D. 83

Answer: D

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1. For a radioactive material, half-life is 10 minutes. If initially there are 600 number of nuclei, the time taken (in minutes) for the disintegration of 450 nuclei is.

A. 30

B. 10

C. 20

D. 15

Answer: C

2. $._6^{12}C$ absorbs an energenic neutron and emits beta particles. The resulting nucleus is.

A. $_7N^{14}$

B. $_7N^{12}$

C. $_5B^{13}$

D. $_6C^{13}$

Answer: B

3. One milligram of matter is converted into energy. The energy released will be

A. 90 J

B. 9×10^3 J

C. 9×10^5 J

D. 9×10^6 J

Answer:

4. In the nuclear decay given below

$$._Z^A X \rightarrow ._{Z-1}^A Y \rightarrow ._{Z-1}^{A-4} B^* \rightarrow ._{Z-1}^{A-1} B,$$
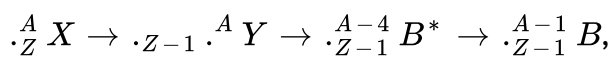
the particle emitted in the sequence are

A. γ, β, α

B. β, γ, α

C. α, β, γ

D. $\beta, \alpha\gamma$

Answer: D

---

5. The number of beta particles emitter by radioactive sustance is twice the number of alpha particles emitter by it. The resulting daughter is an

    A. isomer of parent

    B. isotone of parent

    C. isotope of parent

    D. isobar of parent

Answer: C

---

6. A saample of radioactive elements contains 4×10^{10} active nuclei. If half-life of element is 10 days, then the number of decayed nuclei after 30

days is

A. 0.5×10^{16}

B. 2×10^{16}

C. 3.5×10^{16}

D. 1×10^{16}

Answer: C

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7. A sample of an element is 10.38 g. If half-life of element is 3.8 days, then after 19 days how much quantity of element remains?

A. 0.151g

B. 0.32 g

C. 1.51 g

D. 0.16 g

Answer: B

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8. The mass of proton is $1.0073u$ and that of neutron is $1.0087u$ ($u = $ atomic mass unit). The binding energy of $._2 He^4$ is (mass of helium nucleus $= 4.0015u$)

A. 0.0305 erg

B. 28.4 MeV

C. 0.061 u

D. 0.0305 J

Given helium nucleus mass $=4.0015$ u

Answer: B

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9. A radioactive substance decays to $\left(\dfrac{1}{16}\right)^{th}$ of its initial activity in 40 days. The half-life of the radioacctive substance expressed in days is

A. 2.5

B. 5

C. 10

D. 20

Answer: C

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10. If in a nuclear fusion process the masses of the fusing nuclei be m_1 and m_2 and the mass of the resuktant nucleus be m_3, then

A. $m_3 = |m_1 - m_2|$

B. $m_3 < (m_1 + m_2)$

C. $m_3 > (m_1 + m_2)$

D. $m_3 = m_1 + m_2$

Answer: A

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11. In the reaction $._1^2 H + ._1^3 H \rightarrow ._2^4 He + ._0^1 n$, if the binding energies of $._1^2 H$, $._1^3 H$ and $._2^4 He$ are respectively a, b and c (in MeV), then the energy (in MeV) released in this reaction is.

A. a+b-c

B. c+a-b

C. c-a-b

D. a+b+c

Answer: B

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12. In a radioactive material the activity at time t_1 is R_1 and at a later time t_2, it is R_2. If the decay constant of the material is λ, then

A. $R_1 = R_2$

B. $R_1 = R_2 e^{-\lambda(t_1 - t_2)}$

C. $R_1 = R_2 e^{\lambda(t_1 - t_2)}$

D. $R_1 = R_2 \left(\dfrac{t_1}{t_2} \right)$

Answer: B

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13. The binding energy of deuteron is 2.2 MeV and that of $._2^4 He$ is 28 MeV. If two deuterons are fused to form one $._2^4 He$, th n the energy released is

A. 30.2 MeV

B. 25.8 MeV

C. 23.6 MeV

D. 19.2 MeV

Answer: C

14. The fossil bone has a $.^{14}C : .^{12}C$ ratio, which is $\left[\dfrac{1}{16}\right]$ of that in a living animal bone. If the half -life of $.^{14}C$ is 5730 years, then the age of the fossil bone is :

A. 11,460 years

B. 17,190 years

C. 22,920 years

D. 45,840 yrs

Answer: C

15. Half-lives of two radioactive substances A and B are respectively 20 minutes and 40 minutes. Initially, he sample of A and B have equal number of nuclei. After 80 minutes the ratio of the remaining number of A and B nuclei is :

    A. $4:1$

    B. $1:16$

    C. $1:1$

    D. $1:4$

Answer: D

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16. If the binding energy of the deuterium is $2.23MeV$. The mass defect given in a.m.u. is.

    A. 0.0024

B. 0.0012

C. -0.0012

D. -0.0024

Answer: A

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17. The binding energy of the innermost electron in tungsten is $40keV$. To produce characteristic X - rays using a tungsten target in an X - rays tube the potential difference V between the cathode and the anti - cathode should be

A. $V \geq 40$ kV

B. $V < 40$ kV

C. $V > 40$ kV

D. $V \leq 40$ kV

Answer: C

---

18. The rest energy of an electron is 0.511 MeV. The electron is accelerated

from rest to a velocity 0.5 c. The change in its energy will be

A. 0.105 MeV

B. 0.079 MeV

C. 0.051 MeV

D. 0.026 MeV

Answer: B

---

19. Two radioactive materials X_1 and X_2 have decay constants 5λ and λ

respectively. If initially they have the same number of nuclei, then the

ratio of the number of muclei of X_1 to that of X_2 will be $\dfrac{1}{e}$ after a time

A. $\dfrac{1}{2}\lambda$

B. $\dfrac{1}{4\lambda}$

C. $\dfrac{e}{\lambda}$

D. λ

Answer: B

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20. The activity of a radioactive sample is measures as N_0 counts per minute at $t = 0$ and N_0/e counts per minute at $t = 5 \min$. The time (in minute) at which the activity reduces to half its value is.

A. $5 \log_{10} 2$

B. $5 \log_e 2$

C. $\log_e 2/5$

D. $5/\log_e 2$

Answer: B

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21. The mass of a $._3^7 Li$ nucleus is $0.042u$ less than the sum of the masses of all its nucleons. The binding energy per nucleon of $._3^7 Li$ nucleus is nearly

A. 3.9 MeV

B. 26 MeV

C. 46 MeV

D. 5.6 MeV

Answer: D

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22. An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nucleus of charge Ze . Then the distance of closed approach for the alpha nucleus will be proportional to

    A. 1/m

    B. $\dfrac{1}{v^4}$

    C. 1/Ze

    D. v^2

Answer: A

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23. The half-life of a radioactive isotope X is 50 years. It decays to another element Y which is stable. The two elements X and Y were found to be in the ratio of $1:15$ in a sample of a given rock. The age of the rock was estimated to be

    A. 150 years

B. 200 years

C. 250 years

D. 100 years

Answer: B

24. The power obtained in a reactor using U^{235} disintergration is $1000kW$. The mass decay of U^{235} per hour is

A. 10 microgram

B. 20 microgram

C. 40 microgram

D. 1 microgram

Answer: C

25. A radioactive nucleus of mass M emits a photon of frequency v and the nucleus recoils. The recoil energy will be

A. $Mc^2 - hv$

B. $h^2v^2/2Mc^2$

C. zero

D. hv

Answer: B

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26. If the nuclear radius of $.^{27}A1$ is 3.6 Fermi, the approximate nuclear radius of $64Cu$ in Fermi is :

A. 3.6

B. 2.4

C. 1.2

D. 4.8

Answer: D

---

27. A certain mass of hydrogen is changes to helium by the process of fusion. The mass defect in fusion reaction is $0.02866u$. The energy liberated per u is (given $1u = 931MeV$)

A. 26.7 MeV

B. 6.675 MeV

C. 13.35 MeV

D. 2.67 MeV

Answer:

28. The binding energy per nucleon of $._3^7 Li$ and $._2^4 He$ nuclei are 5.60 MeV and 7.06 MeV, respectively. In the nuclear reaction $._3^7 Li + ._1^1 H \rightarrow ._2^4 He + ._2^4 He + Q$, the value of energy Q released is

A. 19.6 MeV

B. -2.4 MeV

C. 8.4 MeV

D. 17.3 MeV

Answer: D

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29. A radio isotope X with a half-life 1.4×10^9 years decays of Y which is stable. A sample of the rock from a cave was found to contain X and Y in the ratio $1:7$. The age of the rock is.

A. 19.6×10^9 years

B. 3.92×10^9 years

C. 4.20×10^9 years

D. 8.40×10^9 years

Answer: C

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30. If radius of the $^{27}_{13}Al$ nucleus is taken to be R_{Al}, then the radius of $^{125}_{53}Te$ nucleus is nearly

A. $\dfrac{5}{3} R_{Al}$

B. $\dfrac{3}{5} R_{Al}$

C. $\left(\dfrac{13}{53}\right)^{1/3} R_{Al}$

D. $\left(\dfrac{53}{13}\right)^{1/3} R_{Al}$

Answer: A

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31. Radioactive material 'A' has decay constant '8λ' and material 'B' has decay constant 'lamda'. Initial they have same number of nuclei. After what time, the ratio of number of nuclei of material 'B' to that 'A' will be $\dfrac{1}{e}$?

A. $\dfrac{1}{\lambda}$

B. $\dfrac{1}{7\lambda}$

C. $\dfrac{1}{8\lambda}$

D. $\dfrac{1}{9\lambda}$

Answer: B

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Competition File Jee Main Other State Boards For Engineering Entrances

1. A radioactive nuclei with decay constant 0.5 nuclei/s is being produced at a constant rate of 100 nuclei/s. If at t = 0 there were no nuclei, the time when there are 50 nuclei is

A. 1 s

B. $2\ln\left(\dfrac{4}{3}\right)s$

C. ln 2 s

D. $\ln\left(\dfrac{4}{3}\right)s$

Answer: B

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2. Let N_β be the number of β particles emitted by 1 gram of Na^{24} radioactive nuclei (half life $= 15$ hrs) in 7.5 hours, N_β is close to (Avogadro number $= 6.023 \times 10^{23}$ / g. mole) :-

A. 6.2×10^{21}

B. 7.5×10^{21}

C. 1.25×10^{22}

D. 1.75×10^{22}

Answer: B

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3. A piece of wood form the ruins of an ancient building was found to have a C^{14} activity of 12 disintegrations per minute per gram of its carbon content. The C^{14} activity of the living wood is 16 disintegrations/minute/gram. How long ago did the trees, from which the wooden sample came, die? Given half-life of C^{14} is 5760 years.

A. 1,672 years

B. 2,391 years

C. 3,291 years

D. 4,453 years

Answer: B

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4. A piece of wood from a recently cut tree shows 20 decays per minute. A wooden piece of same size placed in a museum (obtained from a tree cut many years back) shows 2 decays per minute. If half-life of C^{14} is 5,730 years, then age of the wooden piece placed in the museum is approximately

    A. 10,439 years

    B. 13,094 years

    C. 19,039 years

    D. 39,049 years

Answer: C

5. The ratio of mass densities of nuclei of ^{40}Ca and ^{16}O is close to :

A. 0.1

B. 5

C. 2

D. 1

Answer: D

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6. The 'rad' is the correct unit used to report the measurement of :

A. the rate of decay of radioactive source

B. ability of y-rays to produce ions in target

C. the energy delivered by radiation to target

D. the biological effect of radiation

Answer: C

7. The energy spectrum of β - particle [number $N\text{€}$ as a function of β - energy E] emitted from a radioactive source is

A.

B.

C.

D.
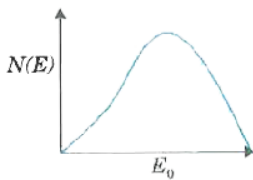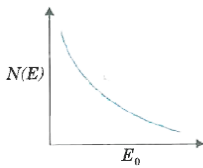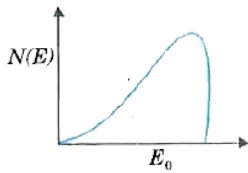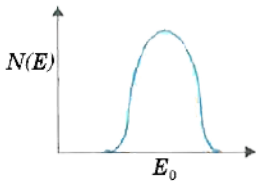
Answer: D

8. The half-life period of a radio-active element X is same as the mean life time of another radio-active element Y. Initially they have the same number of atoms. Then:

A. Y decays faster than X

B. X and Y decay equally initially

C. X and Y decay at same rate always

D. X will decay faster than Y

Answer: A

9. A solution containing active cobalt $\frac{60}{27}$ Co having activity of $0.8\mu Ci$ and decay constant λ is injected in an animal's body. If $1cm^3$ of blood is drawn from the animal's body after 10hrs of injection , the activity found was 300 decays per minute. What is the volume of blood that is flowing in the body ? ($1Ci = 3.7 \times 10^{10}$ decays per second and at $t = 10$ hrs $e^{-\lambda t} = 0.84$)

A. 4 litres

B. 6 litres

C. 5 litres

D. 7 litres

Answer: C

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10. Half-lives of two radioactive elements A and B are 20 minutes and 40 minutes respectively. Initially, the samples have equal number of nuclei.

After 80 minutes, the ratio of decayed numbers of A and B nuclei will be

A. $1:16$

B. $4:1$

C. $1:4$

D. $5:4$

Answer: C

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11. If M_o is the mass of an oxygen isotope $_8O^{17}$, M_p and M_N are the masses of a proton and neutron respectively, the nuclear binding energy of the isotope is:

A. $(8M_P + 9M_N - M_O)c^2$

B. $M_O c^2$

C. $(M_O - 17M_N)c^2$

D. $(M_O - 8M_P)c^2$

Answer: A

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12. The alongside is a plot of binding energy per nucleon E_b ,against the nuclear mass M,A,B,C,D,E,F correspond to different nuclei. Consider four reactions.

(i) A + B $\rightarrow$ C +ε (ii) C $\rightarrow$ A + B + ε
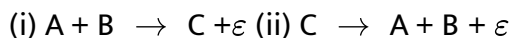
(iii) D + E $\rightarrow$ F + ε (iv) F $\rightarrow$ D + E + ε where ε is the energy released. In which reactions , is ε positive?

A. (ii) and (iv)

B. (ii) and (iii)

C. (i) and (iv)

D. (i) and (iii)

Answer: C

13. At some instant, a radioactive sample S_1 having an activity 5 μCi has twice the number of nuclei as another sample S_2 which has an activity of 10 μCi. The half lives of S_1 and S_2 are :

  A. 5 years and 20 years, respectively

  B. 20 years and 5 years, respectively

  C. 20 years and 10 years, respectively

  D. 10 years and 20 years, respectively

Answer: B

14. The half life of a radioactive substance is 20 minutes . The approximate time interval $(t_2 - t_1)$ between the time t_2 when $\dfrac{2}{3}$ of it had decayed and time t_1 when $\dfrac{1}{3}$ of it had decay is

A. 14 min

B. 20 min

C. 28 min

D. 7 min

Answer: B

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15. Assume that a neutron breaks into a proton and an electron. The energy released during this process is (mass of neutron $= 1.6725 \times 10^{-27}$ kg, mass of proton $= 1.6725 \times 10^{-27} kg$, mass of electron $= 9 \times 10^{-31} kg$)

A. 5.4 MeV

B. 0.51 MeV

C. 7.10 MeV

D. 6.30 MeV

Answer: B

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16. The mass defect of He_2^4 He is 0.03 u. The binding energy per nucleon

of helium (in MeV) is

A. 2.793

B. 69.825

C. 6.9825

D. 27.93

Answer: C

17. Two deuterons udnergo nuclear fusion to form a Helium nucleus. Energy released in this process is : (given binding energy per nucleon for deuteron = 1.1 MeV and for helium = 7.0 MeV)

A. 30.2 MeV

B. 32.4 MeV

C. 23.6 MeV

D. 25.8 MeV

Answer: C

18. Imagine that a reactor converts all given mass into energy and that it operates at a power level of 10^9 watt. The mass of the fuel consumed per hour in the reactor will be (velocity of light, c is 3×10^8 m/s)

A. 0.96 g

B. 0.8 g

C. 4×10^{-2} g

D. 6.6×10^{-5} g

Answer: C

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19. A radioactive nucleus A with a half life T, decays into nucleus B. At t=0, there is no nucleus B. At somewhat t, the ratio of the number of B to that of A is 0.3 . Then, t is given by

A. $t = \dfrac{T}{2} \dfrac{\log 2}{\log 1.3}$

B. $t = T \dfrac{\log 1.3}{\log 2}$

C. $t = T \log(1.3)$

D. $t = \dfrac{T}{\log(1.3)}$

Answer: B

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1. In a radioactive sample. $._{19}^{40}K$ nuclei either decay into stable $._{20}^{40}Ca$ nuclei with decay constant 4.5×10^{-10} per year or into stable $._{18}^{40}Ar$ nuclei with decay constant 0.5×10^{-10} per year. Given that in this sample all the stable $._{20}^{40}Ca$ and $._{18}^{40}Ar$ nuclei are produced by the $._{19}^{40}K$ nuclei only. In time $t \times 10^9$ years. If the ratio of the sum of stable $._{20}^{40}Ca$ and $._{18}^{40}Ar$ nuclei to the radioactive $._{19}^{40}K$ nuclei is 99. The value of t will be. [Given : In 10 = 2.3]

A. 9.2

B. 1.15

C. 0.02

D. 0.01

Answer: A

2. If the measurement errors in all the independent quantities are known, then it is possible to determine the error in any dependent quantity. This is done by the use of series expansion and truncating the expansion at the first power of the error. For example, consider the relation $z = x/y$.If the errors in x, y and z are Δx, Δy and Δz, respectively, then

$$z \pm \Delta z = \frac{x \pm \Delta x}{y \pm \Delta y} = \frac{x}{y}\left(1 \pm \frac{\Delta x}{x}\right)\left(1 \pm \frac{\Delta y}{y}\right)^{-1}.$$

The series expansion for $\left(1 \pm \frac{\Delta y}{y}\right)^{-1}$, to first power in $\Delta y/y$. is $1 \pm (\Delta y/y)$. The relative errors in independent variables are always added. So the error in z will be

$$\Delta z = z\left(\frac{\Delta x}{x} + \frac{\Delta y}{y}\right).$$

The above derivation makes the assumption that $\Delta x/x < < 1, \Delta y/y < < 1$. Therefore, the higher powers of these quantities are neglected.

In an experiment the initial number of radioactive nuclei is 3000. It is

found that 1000 ± 40 nuclei decayed in the first 1.0 s. For $|x| < < 1, \text{In}(1 + x) = x$ up to first power in x. The error $\Delta\lambda$, in the determination of the decay constant λ, in s^{-1}, is

A. 0.04

B. 0.03

C. 0.02

D. 0.01

Answer: C

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3. The electrostatic energy of Z protons uniformly distributed throughout a spherical nucleus of radius R is given by

$$E = \frac{3Z(Z-1)e^2}{5}(4\pi e_0 R)$$

The measured masses of the neutron $_1^1 H, _7^{15} N$ and $_8^{16} O$ are $1.008665u, 1.007825u, 15.000109u$ and 15.0030 respectively Given that the ratio of both the $_7^{12} N$ and $_8^{15} O$

nucleus are same , 1 u = = 931.5 Me Vc^2 (c is the speed of light) and $e^2/(4\pi e_0) = 1.44 MeV$ fm Assuming that the difference between the binding energies of $_-7^{15}N$ and $_-(8)^{\wedge}(15)$ O ` is purely due to the electric energy , The radius of the nucleus of the nuclei is

    A. 2.85 fm

    B. 3.03 fm

    C. 3.42 fm

    D. 3.80 fm

Answer: C

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Competition File Multiple Choice Questions With More Than One Correct Answer

1. When a nucleus in an atom undergoes a radioactive decay, the electronic energy levels of the atom.

A. change only forβ^- emieeion

B. do not change for γ emission

C. change for α and β emission and not for y emission

D. change for β^- and β^+ emission only.

Answer: B::C

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2. Two radioactive samples A and B have same number of atoms initially. After 6 hours, I/8th of sample A and I/32th of sample B remains. The number of half-lives of A and B are n_1 and n_2 The ratio of half-lives of A and B is

A. $\dfrac{5}{7}$

B. $\dfrac{n_2}{n_1}$

C. $\dfrac{n_1}{n_2}$

D. $\dfrac{5}{3}$

Answer: B::D

---

3. Two small nuclei of mass m fuse together to form a resulting nucleus P

The mass of nucleus P is (the energy released is E)

A. $2m - \dfrac{E}{c^2}$

B. $2m + \dfrac{E}{c^2}$

C. $\dfrac{2m}{c^2} + \dfrac{E}{c^2}$

D. $\dfrac{2mc^2 - E}{c^2}$

Answer: A::D

---

4. Which of the following is/are incorrect?

A. In pair annihilation of an electron with position, linear momentum is conserved.

B. Stable nuclei can never have more protons than neutrons.

C. The mass of a He atom is greater than the sum of masses of a proton and an electron.

D. Neutron reproduction factor is less than unity for a supercritical stage in chain reaction.

Answer: C::D

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5. We have two nuclei $_4X^8$ and $_5Y^9$.

A. Nuclei X is more stable than Y.

B. The stability of both X and Y is equal

C. Nuclei Y is more stable than X.

D. Nothing can be said.

Answer: A

---

6. The effective mass of a photon with frequency 6.2×10^{15} Hz is

   A. 4.25×10^{-35} kg

   B. 45.4×10^{-36} kg

   C. 4.54×10^{-35} kg

   D. 6.9×10^{-20} kg

Answer: B::C

7. The binding energy per nucleon of $_7N^{14}$ nucleus is:

(Mass of $_7N^{14} = 14.00307u$)

mass of proton = 1.007825 u

mass of neutron = 1.008665 u

A. 7.471 MeV

B. 8.471 MeV

C. 11.9×10^{-13} J

D. 12.9×10^{-9} J

Answer: A::C

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8. Which of the following are correct nuclear reactions?

A. $_{27}Co^{60} \rightarrow {}_{28}Ni^{60} + {}_{-1}e^0 + \bar{v}$

B. $_3Li^7 + {}_1H^1 \rightarrow {}_2Be^8 \rightarrow 2, {}_2He^4 + {}_{-1}e^0$

C. $_1H^2 + \gamma \rightarrow {_1H^1} + {_0n^1}$

D. $_1H^1 + {_1H^1} \rightarrow {_1H^2} + {_{-1}e^0} + {_0n^1} + 2.5$ MeV
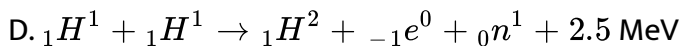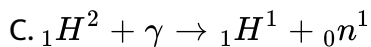
Answer: A::C

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9. In a radioactive decay chain, $._{90}^{232}Th$ nucleus decays to $._{82}^{212}Pb$ nucleus. Let N_α and N_β be the number of α and β- particles, respectively, emitted in this decay process. Which of the following statements is (are) true ?

A. $N_\alpha = 5$

B. $N_\alpha = 6$

C. $N_\beta = 2$

D. $N_\beta = 4$

Answer: A::C

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Competition File Multiple Choice Questions Based On A Given Passage Comprehension

1. Radioactive elements whose nuclei are unstable and atoms of such elements emit α-particles or β-particles along with the γ-rays. Due to emission of α-particles or β-particles, atomic number and atomic mass are changed.

We cannot speed up or slow down this process by any physical or chemical change. It means we cannot affect radioactivity by changing temperature or pressure.

Radioactivity is a spontaneous process of nuclear disintegration.

Lead is heaviest stable atom. In fact all radioactive elements are finally converted into lead.

In β^- decay

A. mass number remains unchanged and atomic number increases by 1.

B. mass number increases by 1 and atomic number remains

   unchanged.

C. atomic number increases by 2 and mass number remains

   unchanged.

D. atomic number decreases by 1 and mass number increases by 1.

Answer: A

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2. Radioactive elements whose nuclei are unstable and atoms of such elements emit α-particles or β-particles along with the γ-rays. Due to emission of α-particles or β-particles, atomic number and atomic mass are changed.

We cannot speed up or slow down this process by any physical or chemical change. It means we cannot affect radioactivity by changing temperature or pressure.

Radioactivity is a spontaneous process of nuclear disintegration.

Lead is heaviest stable atom. In fact all radioactive elements are finally converted into lead.

During a decay,

A. mass number remains unaffected and atomic number increases by 2

B. mass number increases by 4 and atomic number decreases by 2.

C. mass number increases by 4 and atomic number decreases by 1.

D. mass number decreases by 4 and atomic number decreases by 2.

Answer: D

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3. Radioactive elements whose nuclei are unstable and atoms of such elements emit α-particles or β-particles along with the γ-rays. Due to emission of α-particles or β-particles, atomic number and atomic mass are changed.

We cannot speed up or slow down this process by any physical or

chemical change. It means we cannot affect radioactivity by changing temperature or pressure.

Radioactivity is a spontaneous process of nuclear disintegration.

Lead is heaviest stable atom. In fact all radioactive elements are finally converted into lead.

The particle P emitted in the reaction is

$$_ZX^A \rightarrow _{z-1}Y^A + P + v$$

A. β^{-1} particles

B. β^+ particles

C. antineutrino

D. proton

Answer: B

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4. Radioactive elements whose nuclei are unstable and atoms of such elements emit α-particles or β-particles along with the γ-rays. Due to

emission of α-particles or β-particles, atomic number and atomic mass are changed.
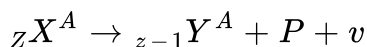
We cannot speed up or slow down this process by any physical or chemical change. It means we cannot affect radioactivity by changing temperature or pressure.

Radioactivity is a spontaneous process of nuclear disintegration.

Lead is heaviest stable atom. In fact all radioactive elements are finally converted into lead.

Complete the reaction $_1H^1 + _7N^{15} \rightarrow$ .... $+ _2He^4$

A. $_6C^{12}$

B. $_7N^{14}$

C. $_6C^{13}$

D. $_8N^{16}$

Answer: A

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5. The half-life is related to the decay constant by the relation.

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

The average life of a sample is expressed by the relation

$$\tau = \frac{1}{\lambda}$$

The average life and half-life are related as

A. $T_{1/2} = 1.44\tau$

B. $\tau = 1.44T_{1/2}$

C. $T_{1/2} = \frac{1}{2}\tau$

D. $\tau = \frac{1}{2}T_{1/2}$

Answer: B

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6. As radioactive substances undergo continuous decay, number of nuclei in a sample goes on decreasing. The time interval in which number of nuclei in a sample is reduced to half of its initial value is the half-life of

the sample. The half-life is related to the decay constant by the relation.

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

The average life of a sample is expressed by the relation

$$\tau = \frac{1}{\lambda}$$

The half-life of radioactive samples can be

    A. only between 10 s and 100 s

    B. only between 1 year and 5 years

    C. between fraction of a second and several million years

    D. only between 100 years and 1,000 years.

Answer: C

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7. As radioactive substances undergo continuous decay, number of nuclei in a sample goes on decreasing. The time interval in which number of nuclei in a sample is reduced to half of its initial value is the half-life of the sample. The half-life is related to the decay constant by the relation.

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

The average life of a sample is expressed by the relation

$$\tau = \frac{1}{\lambda}$$

If the half-life of a radioactive sample is 138.6 days, then mean life of the sample is

A. 199.58 days

B. 1200 days

C. 1999.58 days

D. 500 days

Answer: A

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8. As radioactive substances undergo continuous decay, number of nuclei in a sample goes on decreasing. The time interval in which number of nuclei in a sample is reduced to half of its initial value is the half-life of the sample. The half-life is related to the decay constant by the relation.

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

The average life of a sample is expressed by the relation

$$\tau = \frac{1}{\lambda}$$

The decay constant of a radioactive substance having half-life 2 minutes is

A. 0.3465 min^{-1}

B. 0.1234 min^{-1}

C. 0.4165 min^{-1}

D. 0.4810 min^{-1}

Answer: A

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Competition File Assertion Reason Type Questions

1. Statement: The neutrons are better initiater of nuclear reactions than protons, deutrons, deutrons or $\alpha -$ particles.

Explanation: Neutrons being uncharged particles, not exert repulsive forces form nucleus.

A. If both assertion and reason are correct and reason is a correct

explanation o f the assertion.

B. If both assertion and reason are correct but reason is not the

correct explanation o f assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct

Answer: A

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2. Is free neutron a stable particle ? If not, what is its mode of decay?

A. If both assertion and reason are correct and reason is a correct

explanation o f the assertion.

B. If both assertion and reason are correct but reason is not the

correct explanation o f assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct

Answer: D

3. Assertion: Nuclear density is greater than atomic density.

Reason: Nuclear size (volume) is greater than atomic size.

A. If both assertion and reason are correct and reason is a correct

explanation o f the assertion.

B. If both assertion and reason are correct but reason is not the

correct explanation o f assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct

Answer: C

4. Assertion : γ-rays have very high penetrating power.

Reason: γ-are high energy radiator.

A. If both assertion and reason are correct and reason is a correct explanation o f the assertion.

B. If both assertion and reason are correct but reason is not the correct explanation o f assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct

Answer: C

5. The function of the cadmium rod in a nuclear reactor is

    A. If both assertion and reason are correct and reason is a correct explanation o f the assertion.

    B. If both assertion and reason are correct but reason is not the correct explanation o f assertion.

    C. If assertion is correct but reason is incorrect.

    D. If assertion is incorrect but reason is correct

Answer: D

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6. Assertion: Nuclei above bismuth-209 are unstable irrespective o f their N : Z ratio.

Reason: The force of repulsion between protons is greater than the attractive force between nucleons in nuclei above bismuth-209.

A. If both assertion and reason are correct and reason is a correct explanation o f the assertion.

B. If both assertion and reason are correct but reason is not the correct explanation o f assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct

Answer: A

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7. Water is used as a moderator in nuclear reactor.

Moderator is a light substance that absorb neutrons.

A. If both assertion and reason are correct and reason is a correct explanation o f the assertion.

B. If both assertion and reason are correct but reason is not the

correct explanation o f assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct

Answer: C

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8. Why do stable nuclei never have more protons than neutrons ?

A. If both assertion and reason are correct and reason is a correct

explanation o f the assertion.

B. If both assertion and reason are correct but reason is not the

correct explanation o f assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct

Answer: A

9. Assertion: Out of $_1He^3$ and $_7He^3$, the binding energy of $_1He^3$ is greater than $_2He^8$.

Reason: Inside the nucleus of $_1H^3$, there is more repulsion than inside the nucleus of $_2He^4$.

A. If both assertion and reason are correct and reason is a correct explanation o f the assertion.

B. If both assertion and reason are correct but reason is not the correct explanation o f assertion.

C. If assertion is correct but reason is incorrect.

D. If assertion is incorrect but reason is correct

Answer: B

Competition File Matching Type Questions

List-I		List-II	
P	Number of neutrons in $_{56}Ba^{144}$	1	Atomic number decreases
Q	Number of protons in $_{16}P^{33}$	2	Atomic number increases
R	In β^- decay	3	88
S	In α decay	4	15

1.

A. P-1,Q-2,R-3, S-4

B. P-2,Q-3,R-1,S-4

C. P-2,Q-3,R-4,S-1

D. P-3,Q-4,R-2,S-1

Answer:

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1. Each question contains statements given in two Columns, which are to be a matched. Statements in Column-I are labelled as B A, B, C and D, whereas statements in Column-II C are labelled as p, q, r and s. Match the entries of D Column-I with appropriate entries in Column-II. Each entry in Column-I may have one or more than one correct option from Column-II. The answers to these questions have to be appropriately bubbled as illustrated in the given example, if the correct matches are $A \rightarrow (q, r), B \rightarrow (p, s), C \rightarrow (r, s)$ and $D \rightarrow (q)$

Column I		Column II	
(A)	γ-rays	(p)	EM waves
(B)	α-rays	(q)	No change in mass number
(C)	β-rays	(r)	can cause nuclear reaction
(D)	Positron	(s)	highest penetration power

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2. Each question contains statements given in two Columns, which are to be a matched. Statements in Column-I are labelled as B A, B, C and D, whereas statements in Column-II C are labelled as p, q, r and s. Match the entries of D Column-I with appropriate entries in Column-II. Each entry in Column-I may have one or more than one correct option from Column-II. The answers to these questions have to be appropriately bubbled as illustrated in the given example, if the correct matches are $A \rightarrow (q, r)$, $B \rightarrow (p, s)$, $C \rightarrow (r, s)$ and $D \rightarrow (q)$

Column I			Column II
(A)	Nuclear fusion	(p)	Absorption of thermal neutrons by $_{92}U^{235}$
(B)	Fission in a nuclear reactor	(q)	$_{27}Co^{60}$ nucleus
(C)	β-decay	(r)	Energy production in stars via hydrogen conversion to helium
(D)	γ-ray emission	(s)	Heavy water
		(t)	Neutrino emission

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1. What is the nuclear radius of Te^{125} in fermi if that of Al^{27} is 3.6 fermi?

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2. Half-life of radium is 1,620 years. After how many half-lives 0.75 mg of radium will be disintegrated out of its initial m ass of 1 mg?

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3. माना कि एक स्थिर $_{88}^{226}Ra$ नाभिक अपनी निम्नतम अवस्था (Ground state) α -क्षय करके एक उत्तेजित अवस्था वाले (Excited state) $_{86}^{222}Rn$ नाभिक में क्षयित होता है । उत्सर्जित होने वाले -कण की गतिज ऊर्जा 4.44 Mev है । $_{86}^{222}Rn$ नाभिक फिर Y- क्षय करके अपनी निम्नतम अवस्था में आता है । उत्सर्जितy फोटॉन की ऊर्जा...... keV दिया है , $_{88}^{226}Ra$ का परमाण्विक द्रव्यमान (Atomic mass) = 226.005 u , $_{86}^{222}Rn$ का परमाण्विक

द्रव्यमान = 222.000 u , α कण का परमाण्विक द्रव्यमान = 4.000 u , 1 u = 931 $Me\dfrac{V}{c^2}$, c प्रकाश की गति है .

4. A radioactive substance has half-life of 50 sec and activity of 5×10^{12} becquerel. The time taken for activity to drop to 1.25×10^{12} is $n \times 10^2$ s.

5. In a nuclear explosion, one kg uranium was used. The energy released during the explosion is $E/2 \times 10^{13}$ J if m ass defect involved in the fusion is 0.2%. Find the value of E/2.

6. Half-life of a radioactive substance is 2.9 days and the amount of substance is 10 mg. How many micrograms of the substance will be left

after 29 days.

7. Half-lives of two radioactive elements A and B are 20 minutes and 40 minutes respectively. Initially, the samples have equal number of nuclei. After 80 minutes, the ratio of decayed numbers of A and B nuclei will be

8. For a radioactive material, its activity A and rate of change of its activity of R are defined as $A = \dfrac{-dN}{dt}$ and $R = \dfrac{-dA}{dt}$, where $N(t)$ is the number of nuclei at time t. Two radioactive source P (mean life τ) and Q (mean life 2τ) have the same activity at $t = 0$. Their rates of activities at $t = 2\tau$ are R_p and R_Q, respectively. If $\dfrac{R_P}{R_Q} = \dfrac{n}{e}$, then the value of n is:

9. A freshly prepared sample of a radioisotope of half - life $1386s$ has activity 10^3 disintegrations per second Given that $\ln 2 = 0.693$ the fraction of the initial number of nuclei (expressed in nearest integer percentage) that will decay in the first $80s$ after preparation of the sample is

10. I^{131} is an isotope of iodine that p decays to an isotope of xenon with a half-life of 8 days. A small amount of a serum labelled with I^{131} is injected into the blood of a person. The activity of the amount ofI^{131} injected was2.4×10^5 becquerel (Bq). It is known th a t the injected serum will get distributed uniformly in the blood stream in less th an h alf an hour. After 11.5 hours, 2.5 ml of blood is drawn from person's body, and gives an activity of 115 Bq. The total volume of blood in the person's body, in litres, is approximately (you m ay use$e^x \approx 1 + x$ for $|x| < < 1$ and in $2 \approx 0.7$).

1. Suppose we consider a large number of continers each containing initially 10000 atoms of a radioactive material with a half life of 1 year. After 1 year.

A. all the containers will have 5,000 atoms of the material.

B. all the containers will contain the same number of atoms of the material but that number will only be approximately 5,000.

C. the containers will in general have different numbers of the atoms of the material but their average will be close to 5,000.

D. none of the containers can have more than 5,000 atoms.

Answer:

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2. The gravitational force between a H-atom and another particle of mass m will be given by Newton's law: $F = G\dfrac{M.\,m}{r^2}$, where r is in km and

A. $M = m_{\text{product}} + m_{\text{electron}}$

B. $M = m_{\text{proton}} + m_{\text{electron}} - \dfrac{B}{c^2}\,(B = 13.6eV)$

C. M is not related to the mass of the hydrogen atom.

D. $M = m_{\text{proton}} + m_{\text{electron}} - \dfrac{|V|}{c^2}$ (|V|= magnitude of the potential energy of electron in the H-atom).

Answer:

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3. When a nucleus in an atom undergoes a radioactive decay, the electronic energy levels of the atom.

A. do not change for any type of radioactivity.

B. change for α and β radioactivity but not for γ radioactivity.

C. change for α radioactivity but not for others.

D. change for β radioactivity but not for others.

Answer:

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4. M_x and M_y denote the atomic masses of the parent and the daughter nuclei respectively in a radioactive decay. The Q - value for a $\beta -$ decay is Q_1 and that for a β^+ decay is Q_2. If m_e denotes the mass of an electrons, then which of the following statements is correct?

A. $Q_1 = \left(M_x - M_y \right) c^2$ and $Q_2 = \left(M_x - M_y - 2m_e \right) c^2$

B. $Q_1 - \left(M_x - M_y \right) c^2$ and $Q_2 = \left(M_x - M_y \right) c^2$

C. $Q_1 = \left(M_x - M_y - 2m_e \right) c^2$ and $Q_2 = \left(M_x - M_y + 2m_e \right) c^2$

D. $Q_1 = \left(M_x - M_y + 2m_e \right) c^2$ and $Q_2 = \left(M_x - M_y + 2m_e \right) c^2$

Answer:

▶

5. Tritium is an isotope of hydrogen whose nucleus triton contains 2 neutrons and 1 proton . Free neutrons decay into $p + \bar{e} + \bar{n}$. If one of the neutrons in Triton decays , it would transform into He^3 nucleus. This does not happen. This is because

A. Triton energy is less than that of a He^3 nucleus,

B. the electron created in the beta decay process cannot remain in the nucleus.

C. both the neutrons in triton have to decay simultaneously resulting in a nucleus with 3 protons, which is not a He^3 nucleus.

D. because free neutrons decay due to external perturbations which is absent in a triton nucleus.

Answer:

6. Heavy stable nuclei have more neutrons than protons. This is because of the fact that

    A. neutrons are heavier than protons.

    B. electrostatic force between protons are repulsive.

    C. neutrons decay into protons through beta decay.

    D. nuclear forces between neutrons are weaker than that between

       protons.

Answer:

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7. In a nuclear reactor, moderators slow down the neutrons which come out in a fission process. The moderator used have light nuclei. Heavy nuclei will not serve the purpose because

    A. they will break up.

B. elastic collision of neutrons with heavy nuclei will not slow them

down.

C. the net weight of the reactor would be unbearably high.

D. substances with heavy nuclei do not occur in liquid or gaseous

state at room temperature.

Answer:

8. Fusion processes, like combining two deuterons to form a He nucleus

are impossible at ordinary temperature and pressure. The reasons for

this can be traced to the fact:

A. nuclear forces have short range.

B. nuclei are positively charged.

C. the original nuclei must be completely ionised before fusion can

take place.

D. the original nuclei must first break up before combining with each other.

Answer:

9. Sample of two radioactive nuclides A and B are taken. λ_A and λ_B are the disintergration constants of A and B respectively. In which of the following cases, the two sample can simultaneously have the same decay rate at any time ?

A. Initial rate of decay of A is twice the initial rate of decay of B and

$$\lambda_A = \lambda_B$$

B. Initial rate of decay of A is twice the initial rate of decay of B and

$$\lambda_A > \lambda_B$$

C. Initial rate of decay of B is twice the initial rate of decay of A and

$$\lambda_A > \lambda_B$$

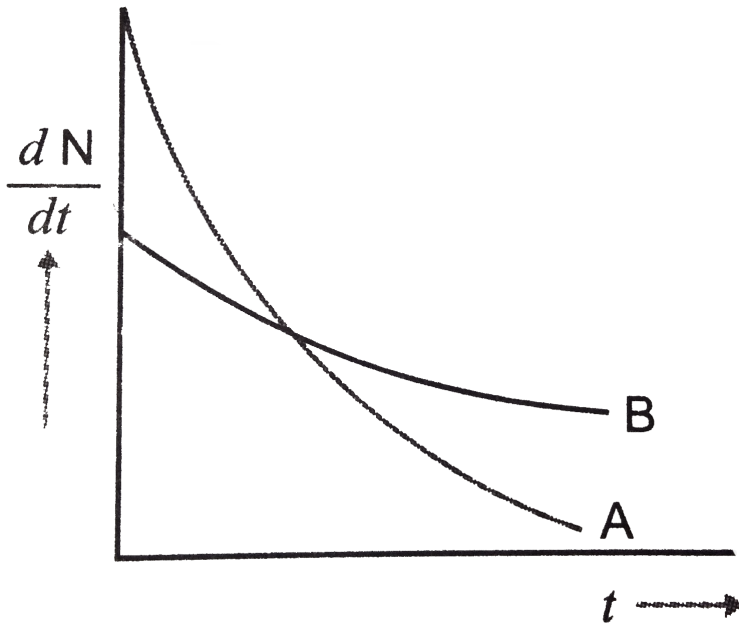D. Initial rate of decay of B is same as the rate of decay of A at t = 2h

and$\lambda_A < \lambda_B$.

Answer:

10. The variation of decay rate of two radioactive samples A and B with time is shown in fig.

Which of the following statements are true?

A. Decay constant of A is greater than that of B, hence A always decays

   faster than B.

B. Decay constant of B is greater than that of A but its decay rate is

   always smaller than that of A.

C. Decay constant of A is greater than that of B but it does not always

   decay faster than B.

D. Decay constant of B is smaller than that of A but still its decay rate becomes equal to that of A at a later instant.

Answer:

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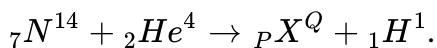**1.** Why are heavy nuclei usually unstable?

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2. The binding energy per nucleon is maximum in the case of.

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3. Find the values of P, Q and X in the following equation:

$_7N^{14} + {_2}He^4 \rightarrow {_P}X^Q + {_1}H^1.$

4. What percentage of a radioactive substance will left undecayed after four half-life periods?

5. What happens to the neutron-proton ratio due to β^- decay?

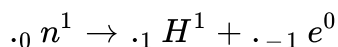**6.** यदि प्रोटॉनों और न्यूट्रॉनों की संख्या प्रत्येक नाभिकीय अभिक्रिया में संरक्षित रहती है तो किसी नाभिकीय अभिक्रिया में किस प्रकार द्रव्यमान-ऊर्जा में (या इसका उल्टा) बदलता है ?

7. Statement-1: No law is violated in the nuclear reaction

$$._0 n^1 \rightarrow ._1 H^1 + ._{-1} e^0$$

Statement-2: Mass number and charge number, both are conserved

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8. What is meant by activity of a radioactive substance? Write its SI unit.

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9. What are delayed neutrons ?

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10. Why the mass of the nucleus is less than the sum of masses of the nucleons?

11. A sample contains $10^{-2}kg$ each of two substances A and B with half lives 4 sec and 8 sec respectively. Their atomic weights are in the ratio $1:2.$ Find the amounts of A and B after an interval of 16 seconds.

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12. यदि N_0 और N समय t=0 और t =1 पर रेडियोसक्रिय कणो की संख्या है, तो-

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13. Draw the curve showing the variation of binding energy per nucleon as a function of mass number A. Explain the stability of the nucleus from the curve .

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14. Draw a plot of potential energy of a pair of nucleons as a function of their separation . Write two important conclusions which you can draw regarding the nature of nuclear forces .

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15. नाभिकीय संलयन क्या है? सूर्य में ऊर्जा इस प्रक्रम द्वारा कैसे उत्पन होती है? आवश्यक समीकरणों की सहायता से समझाइए!

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