PHYSICS

BOOKS - AAKASH SERIES

NUCLEAR PHYSICS

Practice Sheet Linked Comprehension Type Questions

1. From study of elastic collision we understand that if two colliding particles have equal masses they interchange their velocities and energy transfer is maximum if they have equal masses and one is at rest w... other. This principle can be easily used in nuclear reactor to select a moderator. If $m_1 = m_2 = m$ and m_2 at rest then m_1 will stop after colliding with m_2 and m_2 will move with velocity of m_1. In case of nuclear reactor we used a moderator such that neutrons can be slowed down. With above reference answer the following questions

Which is correct statement

A. Soft water can be used as moderator

B. Heavy water is used as moderator

C. Hard water is used as moderator

D. Hard water or Heavy water can be used as moderator

Answer: B

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Practice Sheet Matrix Matching Type Questions

1. Nucleus consists of neutrons and protons, neutrons and protons inside the nucleus interact with each other. They interchange into each other. The forces between them are charge independent. short range, mutual non conservative, strongly attractive. But many particles are emitted like α, β, γ rays and other high energy particles as mesons, leptons, baryons etc. Can you match the classification of particles in Column-1 with their characters in Coloumn-II.

Column-I	Column-II
(A)Chargeless integral spin particle	(p)Pion
(B)Chargeless half spin particle	(q)Photon
$(C)\beta -$ particle	(r)Neutrino
(D)Exchange particle	(s)Positron

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2. The most important use of studying nuclear fission and fusion process was to harness nuclear energy for useful purpose of humanity. Nuclear reactor is the machine designed to harness nuclear energy to electricity. The basic principle involved is fission of uranium to krypton and barium by slow moving neutrons as in following $_0n^1 + {}^{235}_{92}U \rightarrow {}^{96}_{32}Kr + {}^{141}_{56}Ba + 3_0n^1 + Q(200MeV)$ reaction:

But the difficulty is that one neutron striking with ${}^{235}_{92}U$ produces three (2.6 on an average) neutrons which can cause further fission The neutron intensity available for further fission is controlled by measuring reproduction factor defined as the average number of neutrons from each fission the causes further fission. Maximum value of K 2.6. For optimum operation of nuclear reactor, the value of Kis mentioned in

Column-1 for various stages in Columu-Il match the correct columns :

Column-I	Column-II
$(A) K = 1$	(p) Uncontrolled chain reaction
$(B) K < 1$	(q) Critical
$(C) K \geq 1$	(r) Sub critical
$(D) K \approx 25$	(s) Super critical

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Additional Practice Exercise Level I Main Straight Objective Type Questions

1. Activity of a radioactive substance is A_1 at time t_1 and A_2 at time $t_2 (t_2 > t_1)$, then the ratio of f $\frac{A_2}{A_1}$ is:

A. $\frac{t_2}{t_1}$

B. $e^{-\lambda(t_1+t_2)}$

C. $e\left(\frac{t_1 - t_2}{\lambda}\right)$

D. $e^{\lambda(t_1-t_2)}$

Answer: D

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2. The binding energies of the nuclei of $._2^4 He, ._3^7 Li, ._6^{12} C$ and $._7^{14} N$ are 28, 52, 90, 98 MeV respectively. Which of these is most stable.

A. ${}_2^4 He$

B. ${}_3^7 Li$

C. ${}_6^{12} C$

D. ${}_7^{14} N$

Answer: C

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3. In an α -decay the Kinetic energy of α particle is 48 MeV and Q-value of the reaction is 50 MeV. The mass number of the mother nucleus is :- (Assume that daughter nucleus is in ground state).

A. 96

B. 100

C. 84

D. 80

Answer: D

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4. which of these nuclear reaction is possible?

A. $^{23}_{11}Na + ^{1}_{1}H \rightarrow ^{20}_{19}Ne + ^{4}_{2}He$

B. $^{10}_{5}B + ^{4}_{2}He \rightarrow ^{13}_{7}N + ^{1}_{1}H$

C. $^{10}_{5}B + ^{1}_{0}n \rightarrow ^{11}_{5}B + \beta^{-1} + \bar{v}$

D. $^{11}_{7}N + ^{1}_{1}H \rightarrow ^{12}_{6}C + \beta^{-} + \bar{v}$

Answer: D

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5. In a particular fission process of atom at rest Fragents with mass number A_1 and A_2 are produced. Then find ratio of kinetic energies of the fragments?

A. A_2 / A_1

B. $(A_2 / A_1)^2$

C. A_1 / A_2

D. $(A_1 / A_2)^2$

Answer: A

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6. In the mass of $^{228}Th \rightarrow {}^{224}Ra + \alpha$: Atomic mass of ^{228}Th is 228.0287u ^{228}Ra is 224.0202: ^{4}He is 4.0026u. What is Q value of reaction (approximately)

A. 5.49 MeV

B. 4.95 MeV

C. 5.9 MeV

D. 7.36 MeV

Answer: A

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7. The half lives of a radioactive sample are 30 years and 60 years from $\alpha -$ emission and $\beta -$ emission respectively. If the sample decays both by $\alpha -$ emission and $\beta -$ emission emission simultaneously, the time after which only one-fourth of the sample remain is

A. 10 years

B. 20 years

C. 40 years

D. 45 years

Answer: C

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8. The radioactive decay rate of a radioactive element is found to be 10^3 disintegration s^{-1} at a certain time. If the half-life of the element is $1s$, the decay rate after $1s$ is ____ and after $3s$ the decay rate is ____.

A. 500 disintegrations per second

B. 1000 disintegrations per second

C. 250 disintegrations per second

D. 2000 disintegrations per second

Answer: A

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9. Half lives of two isotpers X and Y are know to be 2×10^9 years and 4×10^9 years of these isotopes and currntly the meterical has 20% of X and Y 80% by number on the plabnet. The current age of the planet is

A. 2×10^9 years

B. 4×10^9 years

C. 6×10^9 years

D. 8×10^9 years

Answer: D

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10. A particular nucleus in a large population of identical radioactive nuclei did survive 5 halt lives of that isotope. Then the probability that this surviving nucleus will service the next half life is

A. $\frac{1}{32}$

B. $\frac{1}{5}$

C. $\frac{1}{2}$

D. $\frac{1}{10}$

Answer: C

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Additional Practice Level Ii Lecture Sheet Advanced Straight Objective Type Questions

1. Nucleus A decays into B with decay constant λ_1 and B decays into C with decay constant λ_2 Initially at t=0 number of nuclei of A and B are $2N_0$ and N_0 respectively . At $t = t_0$, number of nuclei of B become constant If at this instant number of buyclei of B are $\frac{3N_0}{2}$

A. $\frac{1}{\lambda_1}\ln\left[\frac{4\lambda_1}{3\lambda_2}\right]$

B. $\frac{1}{\lambda_2}\ln\left[\frac{4\lambda_1}{3\lambda_2}\right]$

C. $(\lambda_1 + \lambda_2)\ln\left[\frac{4\lambda_1}{3\lambda_2}\right]$

D. $\frac{1}{\lambda_1}\ln\left[\frac{4\lambda_1}{3\lambda_2}\right]$

Answer: A

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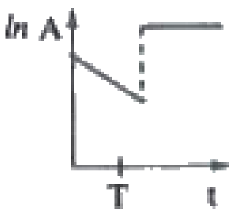
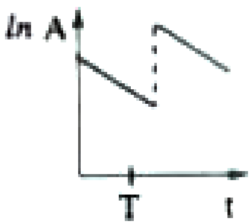
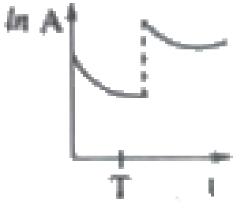
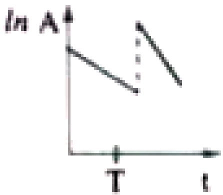
2. At time t=O, some radioactive gas is injected into a sealed vessel. At time T. some more mass of the sam gas is injected into the same vessel. Which one of the following graphs best represetns the variation of the logarithm of the acitivity A of the gas with time t?

A. 

B. 



C.



D.

Answer: B

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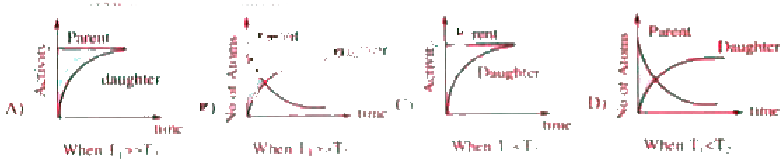
3. A nucleus .A. decays into .b. with half life . T_1. and B decays into .C. with half life T_2, Graphs are drwan between number of atoms/activity versus time which are as shown, then



A. BC are correct

B. ABC are correct

C. AD are correct

D. BCD are correct

Answer: C

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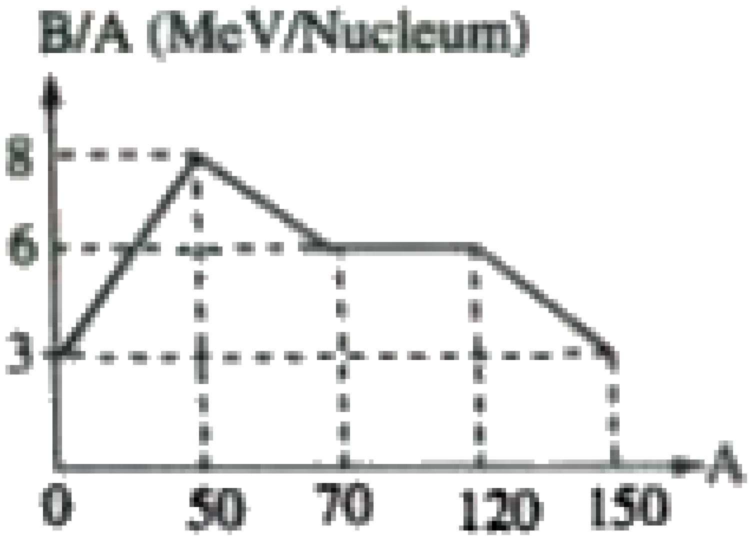
4. Assume that the nuclear binding energy per nucleon (B/A) versus mass number (A) is drawn and is as shown in the figure. Consider a nucleus of A=110. Fission of the nucleus results into 2 fragments Then which of the following sets could be possibly the mass numbers of the resulting nuclei



A) 55 and 55 B) 70 and 40

C) 100 and 10 D) 90 and 20

A. A, B are possible

B. B,C are possible

C. A,B,C,D are possible

D. A only is possible

Answer: A

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5. A radio nuclide A_1 with decay constant λ_1 transforms into a radio nuclide A_2 with decay constant λ_2. Assuming that at the initial moment, the preparation contained only the radio nuclide A_1

(a) Find the equation decribing accumulation of radio nuclide A_2 with time. (b) Find the time interval after which the activity of radio nuclide A_2 reaches its maximum value.

A. $\dfrac{\ln(\lambda_2/\lambda_1)}{\lambda_2-\lambda_1}$

B. $\dfrac{\ln(\lambda_2/\lambda_1)}{\lambda_2\lambda_1}$

C. $\ln(\lambda_2-\lambda_1)$

D. $e^{-(\lambda_1-\lambda_2)}$

Answer: A

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6. A radioactive nucleus undergoes a series of decay according to the scheme. $A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$. If the mass number and atomic number of A are 180 and 72 respectively, then the mass number (x) and atomic and atomic number (y) of A_4 are

A. x= 172: y = 72

B. x = 174, y = 69

C. x = 176, y = 69

D. x = 172: y = 69

Answer: D

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7. Binding energy per nucleon of 1^{H^2} and 2^{He^2} are 1.1 MeV and 7.0 respectively Energy realsed in the process $1^{H^2}+1^{He^4}$ is

A. 2

B. 3

C. 4

D. 6

Answer: A

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8. The energy equivalent to 1 amu is?

A. 6

B. 7

C. 8

D. 5

Answer: C

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9. Calculate output of $._{92}^{235}U$ reactor, if it takes 30 days to use up 2 kg of fuel, and if each fission gives 185 MeV of useable energy. Avogadro's number $= 6 \times 10^{23}$ /mol ?

A. 5

B. 6

C. 7

D. 8

Answer: B

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Additional Practice Level Ii Lecture Sheet Advanced More Than One Correct Answer Type Questions

1. $.^{40}K$ is an unusual isotope, in that it decays by negative beta emission, positive beta emission, and electron capture. Find the Q values for these decays.

A. $Q_1 = Q_2$

B. $Q_1 < Q_2$

C. neutrino emitted in positive β decay is monoenergetic

D. neutrino emitted increases by a factor $\frac{27}{8}$

Answer: D

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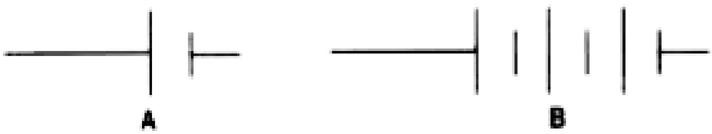
2. What do the following figures represent?



A. A current in a circuit containing a source of constant emf., a pure resistance and a prue inductor after a long time, when the source is open at time t = 0

B. The number of undecayed nuclei in a large population of identical radioactive nuclei

C. The p.d. between the plates of charged capacitor, which is shorted by a pure resistance at time t=0

D. The temperature difference between a body and comparatively slightly cooler enclosure of constant temperature, in which the body is suspended.

Answer: B::C::D

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3. Nucleus A decays into B with decay constant λ_1 and B decays into C with decay constant λ_2 Initially at t=0 number of nuclei of A and B are $2N_0$ and N_0 respectively . At $t = t_0$, number of nuclei of B become constant If at this instant number of buyclei of B are $\frac{3N_0}{2}$

A. $t_0 = \frac{1}{\lambda_1} \ln \frac{4\lambda_1}{3\lambda_2}$

B. $t_0 = \frac{1}{\lambda_2} \ln \frac{4\lambda_1}{3\lambda_2}$

C. $N_A = \frac{3N_0}{2} \frac{\lambda_2}{\lambda_1}$ to $t = t_0$

D. $N_A = \frac{2N_0}{3} \frac{\lambda_2}{\lambda_1}$ at $t = t_0$

Answer: option 4

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4. As an electron makes a transition from an excited state to the ground state of a hydrogen - like atom/ion :

A. It kinetic energy increases but potential energy and total deceases

B. Kinetic energy, potential energy and total energy decreases

C. Kinetic energy decreases, potential energy increases but total energy remains same

D. Kinetic energy and total energy decrease but potential energy increases

Answer: B::C::D

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Additional Practice Level Ii Lecture Sheet Advanced Linked Comprehension Type Questions Passage I

1. If two deuterium nuclei get close enough to each other, the attraction of the strong nuclear force will fuse them to make an isotope of helium. This process releases a huge amount of energy. The range of nuclear force is 10^{-15} m. This is the principle behind the nuclear fusion reactor. The deuterium nuclei moves to fast that, it is not possible to contain them by physical walls. Therefore they are confined magnetically (Assume coulomb law to hold even at 10^{-18} m)

Two deuterium nuclei having same speed undergo a head on collision. Which of the following is closest to the minimum value of v (in km/sec) for which fusion occurs

A. 1000

B. 5000

C. 10000

D. 50000

Answer: C

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2. If two deuterium nuclei get close enough to each other, the attraction of the strong nuclear force will fuse them to make an isotope of helium. This process releases a huge amount of energy. The range of nuclear force is 10^{-15} m. This is the principle behind the nuclear fusion reactor. The deuterium nuclei moves to fast that, it is not possible to contain them by physical walls. Therefore they are confined magnetically (Assume coulomb law to hold even at 10^{-18} m)

Two deuterium nuclei having same speed undergo a head on collision. Which of the following is closest to the minimum value of v (in km/sec) for which fusion occurs

A. 122mT

B. 160M

C. 139mT

D. 212mT

Answer: C

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Additional Practice Level Ii Lecture Sheet Advanced Linked Comprehension Type Questions Passage Ii

1. Nuclei of a radioactive element X are being produced at a constant rate K and this element decays to a stable nucleus Y with a decay constant λ and half-life $T_{1/3}$. At the time $t=0$, there are N_0nuclei of the element X.

The number N_Y of nuclei of Y at time t is .

A. $\dfrac{K+\lambda N_0}{2\lambda}$

B. $2(\lambda N_0 - K)\frac{1}{\lambda}$

C. $\left(\lambda N_0 + \frac{K}{2}\right)\frac{1}{\lambda}$

D. $\frac{\lambda N_a - K}{2\lambda}$

Answer: A

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2. Nulei of radioactive element A are produced at any time t. the element A has decay constant λ. Let N be number of nulei if element A at any time t. At time $t = t_0$ dN/dt is minimum. Then the numbers of nuclei of element A at time $t = t_0$ is

A. $K\frac{\ln 2}{\lambda} + \frac{3}{2}\left(\frac{K - \lambda N_0}{\lambda}\right)$

B. $K\frac{\ln 2}{\lambda} + \frac{1}{2}\left(\frac{K - \lambda N_0}{\lambda}\right)$

C. $K\frac{\ln 2}{\lambda} - \frac{1}{2}\left(\frac{K - \lambda N_0}{\lambda}\right)$

D. $K\frac{\ln 2}{\lambda} - 2\left(\frac{K - \lambda N_0}{\lambda}\right)$

Answer: C

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Additional Practice Level Ii Lecture Sheet Advanced Integer Type Questions

1. For a radioactive material, its activity A and rate of change of its activity of R are defined as $A = \frac{-dN}{dt}$ and $R = \frac{-dA}{dt}$, 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 $\frac{R_P}{R_Q} = \frac{n}{e}$, then the value of n is:

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2. A radioactive material consists nuclides of 3 isotope which decay by $\alpha -$ emission, β- emission and deuteron emission respectively. Their half lives are $T_1 = 400\,\text{sec}$, $T_2 = 800\,\text{sec}$ and $T_3 = 1600$ sec respectively. At t=0, probability of getting $\alpha . \beta$ and deuteron from radio nuclide are equal. If the probability of α emission at t = 1600 seconds is n/13, then find the value of .n. is _____

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3. A radioactive substance .A. is being generated at a constant rate $C(100 \times 10^6$ atoms /sec) it disintegrates at a rate of $\lambda(37dps)$ to form B. Initially there are no A and B atoms. If the number of atoms of B after one mean life of A is 1×10^x atoms, then find the value of x

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Additional Practice Practice Sheet Advanced Straight Objective Type Questions

1. A parent radioactive nucleus A (decay constant λ_A) converts into a radio-active nucleus B of decay constant λ_b, initially, number of atoms of B is zero At any time N_a, N_b are number of atoms of nuclei A and B respectively then maximum velue of N_b.

A. $\frac{3}{2}$

B. $\frac{9}{4}$

C. $\frac{1}{1}$

D. $\frac{\ln 3}{\ln 2}$

Answer: B

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2. There is a stream of neutrons with a kinetic energy of 0.0327eV. If the half-life of neutrons is 700 seconds, the fraction of neutrons that will decay before they travel a distance of 10 Km . (Given mass of neutron $m = 1.6758 \times 10^{-27}$ kg)

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3. A radioactive sample decays with a mean life of 20ms. A capacitor of capacitance $100\mu F$ is charged to some potential and then the plates are connected to a resistance .R.. If the ratio of the charge on the capacitance to the activity of radioactive sample remains constant in time is $R = 100(x)\Omega$, then x=

A. 2

B. 3

C. 4

D. 5

Answer: A

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4. A radioactive element decays by $\beta - emission$. A detector records n beta particles in $2s$ and in next $2s$ it records $0.75n$ beta particles. Find mean life correct to nearest whole number. Given ln $|2| = 0.6931$, ln $|3| = 1.0986$.

A. 3

B. 5

C. 7

D. 6

Answer: C

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5. Some amount of a radioactive substance (half-life = 10 days) is spread inside a room and consequently, the level of radiation becomes 10 times the permissible level for normal occupancy of the room. After how many days will the room be safe for occupation ?

A. 6

B. 7

C. 4

D. 5

Answer: D

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6. The disintegration rate of a certain radioactive sample at any instant is 4750 disintegrations per minute. Five minutes later the rate becomes 2700 per minute. Calculate

(a) decay constant and (b) half-life of the sample

A. 15 min

B. 10 min

C. 3 min

D. 6 min

Answer: A

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7. The mean lives of a radioactive substance are 1620 years and 405 years for α-emission and β-emission, respectively. Find out the time during which three fourths of a sample will decay if it is decaying both by α-emission and β-emission simultaneously.

A. 449.94 years

B. 323 years

C. 350 years

D. 329.68 years

Answer: A

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8. in the chemical analyisis of a rock the mass ratio of two radioacctive isotopes is found to be 100: 1 the mean lives of the two isotope are 4×10^9 yr and 2×10^9 yr, respecively if it is assumed that at the time of formation the atoms of both the isotopes were on equal propartion „

calculate the age of the rock . ratio of the atomic weights of the two isotope is 1.02:1 .

A. 2

B. 8

C. 10

D. 20

Answer: A

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9. A rock is 1.5×10^9 years old. The rock contains $.^{238}U$ which disintegretes to form $.^{236}U$. Assume that there was no $.^{206}Pb$ in the rock initially and it is the only stable product fromed by the decay. Calculate the ratio of number of nuclei of $.^{238}U$ to that of $.^{206}Pb$ in the rock. Half-life of $.^{238}U$ is $4.5 \times 10^9. years.$ (2^(1/3) = 1.259)` .

A. 1

B. 2

C. 4

D. 5

Answer: C

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10. The binding energy per nucleon of deuteron $\left(._1^2 H\right)$ and helium nucleus $\left(._2^4 He\right)$ is $1.1 MeV$ and $7 MeV$ respectively. If two deutron nuclei react to form a single helium nucleus, then the energy released is-

A. 2

B. 6

C. 9

D. 12

Answer: A

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Additional Practice Practice Sheet Advanced More Than One Correct Answer Type Questions

1. Let M_1 and M_2 be the masses of the nuclei ${}_1H^2$ and ${}_2H^4$ respectively. Aslo let m_p and m_n be the masses of proton and neutron respectively.

A. $m_p + m_n < M_1$

B. $2[m_p + m_n] > M_2$

C. $M_2 = 2M_1$

D. $M_2 < 2M_1$

Answer: B

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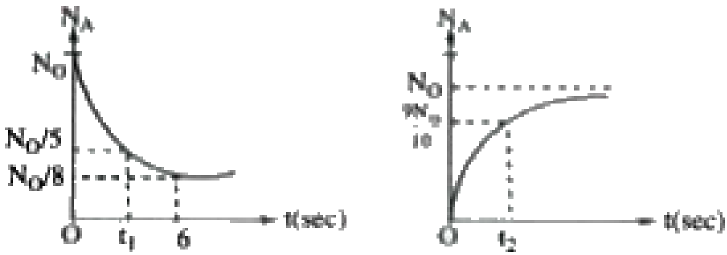
2. In a decay process A decays to B. $A \to B$. Two graphs of number of nuclei of A and B versus time is given then



A. $t_2 - t_1 = 4\,\text{sec}$

B. $t_2 - t_1 = 2\,\text{sec}$

C. $t_1 = 2\log_2 5\,\text{sec}$

D. $t_2 = 2\log_2 100\,\text{sec}$

Answer: B

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3. At a given instant, there are 25% undecayed radioactive nuclei in a sample. After 10 seconds the number of undecayed nuclei reduces to

12.5%, the mean life of the nuclei is

A. The mean life of the nuclei 0.0693 second

B. The mean life of the nuclei is 14.43 second

C. The time internal in undecayed which the number of nuclei further reduce to 16.25% is 40 second

D. The time interval in which the number of undecayed nuclei further reduce to 6.25% is 30 second

Answer: B

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4. A nuclear explosion is designed to deliver MW of heat energy. The explosion is designed with a nuclear fuel ^{235}U to run the reactor to ...This power level if 200 MeV of energy is released for each fission event, then

A. Energy per fission is joule is 3.2×10^{-11}

B. he number of fission events that must be required in a second to attain this power level is 3.125×10^{16}

C. The total number of fusoin events required in one year to maintain at this power level is 9.85×10^{3}

D. The total mass o f uranium fuel needed in one year to maintain the reactor at that power output level is 384.5 gm

Answer: A::B::C::D

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5. 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

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

$._{94}^{244} P_u = 244.064100u$ and $._2^4 He = 4.002603u$. Calculate the power output from a sample of 10^{20} Cm atoms. $(1u = 931 MeV / c^2)$

A. The activity of fission $R = 10^7$

B. The actual rate of fission is 8×10^5 sec

C. The rate of decay of α- particle is 92×10^5 /sec

D. The power output due to $\alpha -$ decay is 4.725×10^7 MeV /sec nd the total power output is $33.16 \mu w$

Answer: A::B::C::D

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Additional Practice Practice Sheet Advanced Linked Comprehension Type Questions Passage I

1. A radionuclide with half - life 1620 s is produced in a reactor at a constant rate of 1000 nuclei per second. During each decay energy, 200 MeV is released. If the production of radionuclides started at t = 0, then the rate of release of energy at t = 3240 s is

A. $N = \frac{PT}{\log_e 2}\left[1 - e^{-\left(\frac{\log_e 2}{t}\right)t}\right]$

B. $N = \frac{PT}{\log_e 2}\left[1 - e^{-\left(\frac{\log_e 4}{t}\right)t}\right]$

C. $N = \frac{PT}{\log_e 4}\left[1 - e^{-\left(\frac{\log_e 2}{T}\right)t}\right]$

D. $N = \frac{PT}{\log_e 2}\left[1 + e^{-\left(\frac{\log_e 2}{T}\right)t}\right]$

Answer: A

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2. A radionuclide with half - life 1620 s is produced in a reactor at a constant rate of 1000 nuclei per second. During each decay energy, 200 MeV is released. If the production of radionuclides started at t = 0, then the rate of release of energy at t = 3240 s is

A. $PE_0\left(1 - e^{-\left(\frac{\log_e 4}{T}\right)t}\right)$

B. $PE_0\left(1 - e^{-\left(\frac{\log_e 2}{T}\right)t}\right)$

C. $PE_0\left(1 + e^{-\left(\frac{\log_e 4}{T}\right)t}\right)$

D. $PE_0\left(1 + e^{-\left(\frac{\log_e 2}{T}\right)t}\right)$

Answer: B

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Additional Practice Practice Sheet Advanced Linked Comprehension Type Questions Passage Ii

1. A nucleus at rest undergoes $\alpha -$ deacy emitting an α -particle of de Brogile wavelength $\lambda = 5.76 \times 10^{-15} m$. If the mass of the daughter nucleus is 223.610 amu and that of the α-particles is $4.002 a\mu$, determine the total kinetic erergy in the final state. Hence, obtian the mass of parent nucleus in amu $(1 a\mu = 931.470 MeV$c^(-2))`.

A. $1.15 \times 10^{-19} kg - ms^{-1}$

B. $1.15 \times 10^{-20} kg - ms^{-1}$

C. $11.5 \times 10^{-25} kg - ms^{-1}$

D. $3.30 \times 10^{-19} kg - m - s^{-1}$

Answer: A

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2. A nucleus at rest undergoes $\alpha -$ deacy emitting an α -particle of de Brogile wavelength $\lambda = 5.76 \times 10^{-15} m$. If the mass of the daughter nucleus is 223.610 amu and that of the α-particles is $4.002 a\mu$, determine the total kinetic erergy in the final state. Hence, obtian the mass of parent nucleus in amu $(1 a\mu = 931.470 MeV$c^(-2))`.

A. 227.605 amu

B. 227.605 kg

C. 227.605 mg

D. 2.27 kg

Answer: A

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3. A nucleus at rest undergoes $\alpha -$ deacy emitting an α -particle of de Brogile wavelength $\lambda = 5.76 \times 10^{-15} m$. If the mass of the daughter nucleus is 223.610 amu and that of the α-particles is $4.002 a\mu$, determine the total kinetic erergy in the final state. Hence, obtian the mass of parent nucleus in amu $(1 a\mu = 931.470 MeV$c^(-2))`.

A. $\frac{P_{\alpha}^{2}(m_{\alpha} + m_{d})}{2 m_{\alpha} m_{d}}, (P_{d} = \text{linear momentum of } \alpha - \text{particle})$

B. $\frac{P_{d}^{2}(m_{\alpha} + m_{d})}{2 m_{\alpha} m_{d}}, (P_{d}:$ linear momentum of daughter nucleus)

C. $10^{-12} J$

D. 6.625 MeV

Answer: A::B::C

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1. Match the following:

	Column A		Column B
(a)	Circular motion	(i)	a running fan
(b)	Periodic motion	(ii)	a car moving in a market
(c)	Vibratory motion	(iii)	movement of the hands of a clock
(d)	Rotatory motion	(iv)	motion of wire of a guitar
(e)	Non uniform motion	(v)	motion of pendulum of a clock

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Additional Practice Practice Sheet Advanced Integer Type Questions

1. In a sample of rock, the ratio of number of ^{206}Pb to ^{238}U nuclei is found to be 0.5. The age of the rock is $(18/n) \times 10^9 \frac{\ln\left(\frac{3}{2}\right)}{\ln 2}$ year (Assume that all the Pb nuclides in he rock was produced due to the decay of Uranium nuclides and $T_{1/2}(^{238}U) = 4.5 \times 10^9$ year). Find n.

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2. The present day abundances (in moles) of the isotopes U^{238} and U^{235} are in the atio of 128 : 1. They have half lives of 4.5×10^9 years and 7×10^8 years respectively. If age of earth in $\frac{49X}{76} \times 10^7$ years, then calculate X (Assume equal moles of each isotope existed at the time of formation of the earth)

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3. A sample of radioactive nuclide A^{150} is having half life 2 hours and produce B^{146} after emitting α particle. Initially in sample only A was present having mass 50 gm. After four hours difference in mass of sample (A + B) is x gm then value of X is.

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Example

1. Calculate the average energy required to extract a nucleon from the nucleus of an α - particle ,proton and neutron are 4.00150 a.m.u 1.00728 a.m.u and 1.00867 amu respectively .

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2. The atomic mass of an alpha particles 4.002603 amu and that of oxygen is 15.994915 amu. Find the energy required to split up the oxygen - 16 nucleus into 4 alpha particles .

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3. Neon -23 decays in the following way ${}_{10}^{23}Ne \rightarrow {}_{11}^{23}Ne + {}_{-1}e^0 + \bar{v}$. Find the minimum and maximum kinetic energy that the beta particle $\left({}_{-1}e^0\right)$ can have . The atomic masses of ${}^{23}Ne$ and ${}^{23}Na$ are 22.9945 u and 22.9898 u, respectively.

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4. Find the Q value of the reaction $P + .^{7}Li \rightarrow .^{4}He + .^{4}He.$ Determine whether the reaction is exothermic or endothermic. The atomic masses of $.^{1}H, .^{4}He$ and $.^{7}Li$ are $1.007825u$, $4.002603u$, and $7.016004u$, respectively.

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5. The kinetic energy of an α-particle which flies out of the nucleus of a Ra^{226} atom in radioactive disintergration is $4.78MeV$. Find the total energy evolved during the eascape of the α-particle

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6. A radioactive isotope X has a half-life of 3s. At t = 0 s, a given sample of this isotope X contains 8000 atoms. Find the time t_1, when 1000 atoms of isotope X remains in the sample.

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7. At time $t = 0$, number of nuclei of a radioactive substance are 100. At $t = 1$ s these numbers become 90. Find the number of nuclei at $t = 2s$.

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8. The activity of a sample of radioactive material is A_1 at time t_1 and A_2 at time $t_2 (t_2 > t_1)$. It mean life is T .

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9. The mean lives of a radioactive substance are 1620 years and 405 years for α-emission and β-emission, respectively. Find out the time during which three fourths of a sample will decay if it is decaying both by α-emission and β-emission simultaneously.

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10. Find the decay constant (in s^{-1}) of $.^{55}Co$radionuclide if its activity is known to decrease 4% per hour. The decay product is non-radioactive.

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11. A F^{32} radio nuclide with half-life $T = 14.3$ days is produced in a reactor at a constant rate $q = 2 \times 10^9$ nuclei per second. How soon after the beginning of production of that radio nuclide will its activity be equal to $R = 10^9$ disintegration per second?

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12. A $.^{118}Cd$ radio nuclide goes through the transformation chain.

$$.^{118}Cd \xrightarrow[30\,\text{min}]{} {}^{118}1n \xrightarrow[45\,\text{min}]{} {}^{118}Sn(stable)$$

The half-lives are written below the respective arrows. At time $t = 0$ only Cd was present. Find the fraction of nuclei transformed into stable over 60 minutes.

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13. Find the minimum kinetic energy of an α-particle to cause the reaction $.^{14}N(\alpha, p).^{17}O$. The masses of $.^{14}N$, $.^{4}He$, $.^{1}H$ and $.^{17}O$ are respectively $14.00307u, 4.00260u, 1.00783u$ and $16.99913u$.

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14. Calculate the energy released by fission from 2g of $._{92}^{235}U$ in kWh. Given that the energy released per fission is 200 MeV.

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15. Calculate the Q - value for the reaction , $_1H^2(d, n)_2He^3$

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16. En electron - positron pair is produced when a γ - ray photon of energy 2.36MeV passes close to a heavy nucleus. Find the kinetic energy carried by each particle produced , as well as its total energy.

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17. A gamma ray photon of energy 1896 MeV annihilates to produce a proton - antiproton pair. If the rest mass of each of the particles involved be 1.007276 a.m.u approximately, find how much K.E each particle will carry ?

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Exercise Very Short Answer Questions

1. Why is a nuclear fusion reaction called a thermo nuclear reaction ?

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Problems Level I

1. Compare the radii of two nuclei with mass number 8 and 64 respectively.

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

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

$= 14.00307 \quad u$

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3. A radioactive nucleus undergoes a series of decays according to the sequence

$$X \xrightarrow{\beta} X_1 \xrightarrow{\alpha} X_2 \xrightarrow{\alpha} X_3.$$

f the mass number and atomic number of X_3 are 172 and 69 respectively. what is the mass numberand atomic number of X ?

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4. If $92^{U^{238}}$ changes to $85^{At^{210}}$ by a series of α and β decays, the number of α and β decays undergone is

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5. Plutonium decays with half life of 24000 years. If plutonium is stored for 72000 years, the fraction of it that remains is

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6. The half - life of $.^{215} At$ is $100 \mu s$. The time taken for the radioactivity of a sample of $.^{215} At$ to decay to $\left(\frac{1}{16}\right)^{\text{th}}$ of its initial value is

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7. The half - life of radium is 1600 years. The time does 1 g of radium take to reduce to 0.125 g is

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8. In a sample of a radioactive substance what fraction of the initial number of nuclei will reamin undercayed after a time $t = \frac{T}{2}$ where T=half-life of rodioactive substance

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9. A radioactive element X converts into another stable element. Y half-life X is 2 h Initially only X is present. After time t, the ratio of atoms of X and Y is found to be $1:4$ then t in hour is

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10. A radioactive substance contains 10^{15} atoms and has an activity of 6.0×10^{11} Bq. What is its half-life?

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11. N_1 atoms of a radioactive element emit N_2 "beta" particles per second The decay constant of the element is (ins^{-1})

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12. After 280 days, the activity of a radioactive sample is 6000 dps. The activity reduces to 3000 dps after another 140 days. The initial activity of the sample in dps is

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13. The binding energies of nuclei X and Y are E_1 and E_2 respectivley . Two atoms of X fuse to give one atom of Y and an energy Q is released.

Then

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14. The binding energies per nucleon for deuteron ($\_1H^2$) and helium ($\_2He^4)are1.1MeV$ and $7.0MeVrespectively. Thee \ne rgyre \le asedwhe$

_2He^4`) is

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15. If a star can convert all the He nuclei completely into oxygen nuclei. The energy released per oxygen nuclei is (Mass of the helium nucleus is 4.0026 amu and mass of oxygen nucleus is 15.9994 amu)

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16. Consider a hypothetical annihilation of a stationary electron with a stationary positron. What is the wavelength of the resulting radiation?

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Problems Level Ii

1. $._{83}^{212}Bi$ decays as per following equation.

$._{83}^{212}Bi \rightarrow_{82}^{208} Ti +_2^4 He$

The kinetic energy of α-particle emitted is $6.802MeV$. Calculate the kinetic energy of Ti recoil atoms.

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2. A nucleus with mass number 220 initially at rest emits an α-particle. If the Q-value of the reaction is $5.5MeV$, calculate the kinetic energy of the α-particle.

(a) 4.4 MeV (b) 5.4 MeV (c) 5.6 MeV (d) 6.5 MeV

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3. In the decay $.^{64}Cu \rightarrow .^{64}Ni + e^{-} + v_1$ the maximum kinetic energy carried by the positron is found to be $0.680MeV$ (a) Find the energy of the neutrino which was emitted together with a positron of energy $0.180MeV$ (b) what is the momentum of this neutrion in $kg-m/s$? Use the formula applicable to photon.

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4. A freshly prepared sample of a certain radioactive isotope has an activity of $10mCi$. After $4.0h$ its activity is $8.00mCi$.

(a) Find the decay constant and half-life

(b) How many atoms of the isotope were contained in the freshly prepared sample?

(c) What is the sample's activity $30.0h$ after it is prepared?

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5. The ratio of molecules mass of two radiactive substances is $\frac{3}{2}$ and the ratio of their decay constant is $\frac{4}{3}$ Then the ratio of their intial activity per mol will be

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6. Two radioactive elements X and Y have half-life periods of 50 minutes and 100 minutes, respectively. Initially, both of them contain equal number of atoms. Find the ratio of atoms left $\frac{N_X}{N_Y}$ after 200 minutes.

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7. The count rate of a radioactive sample falls from $4.0 \times 10^6 s^{-1}$ to $1.0 \times 10^6 s^{-1}$ in 20 hours. What will be the count rate after 100 hours from beginning ?

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8. The half-life of 238 92U undergoing α -decay is 4.5 × 109 years. What is the activity of 1g sample of 238 92U

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9. Half-life of a radioactive substance A is $4days$. The probability that a nuclear will decay in two half-lives is

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10. What is the probability that a radioactive atom having a mean life of $10days$ decays during the fifth day?

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11. A small quantity of solution containing Na^{24} radio nuclide of activity 1 microcurie is injected into the blood of a person. A sample of the blood of volume $1cm^3$ taken after 5 h shows an activity of 296 disintegration per minute. What will be the total value of the blood in the person? Assum that the radioactive solution mixes uniformly in the blood of the person. (Take, 1 curie $= 3.7 \times 10^{10}$ disintegration per second and $e^{-\lambda t} = 0.7927,$ where lamda=` disintegration constant)

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12. Beta decay of a free neutron takes place with a half life of 14 minutes. Then find (a) decay constant (b) energy liberated in the process.

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13. What is the probability of a radioactive nucleus to survive one mean life?

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14. A radioactive isotope is being produced at a constant rate X Half-life of the radioactive substance is Y After some time the number of radiactive nuclie become constant The value of this constant is

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15. A radioactive nucleus is being prodouced at a constant rate α per second. Its decay constant is λ. If N_0 are the number of nuclei at time t =0 then maximum number of nuclei possible are

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16. (a) How much mass is lost per day by a nuclear reactor operated at a 10^9 watt power level?

(b) If each fission releases $200 MeV$, how many fissions occur per second to yield this power level?

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17. Assuming the splitting of U^{235} nucleus liberates $200MeV$ energy, find

(a) the energy liberated in the fission of 1 kg of U^{235} and

(b) the mass of the coal with calorific value of $30kJ/g$ which is equivalent to $1kg$ of U^{235}.

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18. Calculate the Q-value of the fusion reaction

$\hat{} 4He +^4 He \rightarrow^8 Be$

Is such a fusion energetically favourable? Atomic mass of $\hat{} 8Be$ is 8.0053u and that of $\hat{} 4He$ is 4.0026u.

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19. 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 $._1^2 H$ and $._2^4 He$ are 2.0141 atomic mass units and 4.0026 atomic mass units respectively.)

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20. The half-lives of radio isotopes P^{32} and P^{33} are 14 days and 28 days respectively. These radioisotopes are mixed in the ratio of 4:1 of their atoms. It the initial activity of the mixed sample is 3.0 mCi, find the activity of the mixed isotopes after 60 years.

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21. A radioactive material of half-life T was kept in a nuclear reactor at two different instants. The quantity kept second time was twice of the kept first time. If now their present activities are A_1 and A_2 respectively, then their age difference equals

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22. There are two radioactive nuclei A and B A is an alpha emitter and B a beta emitter. Their disintegration constants are in the ratio of atoms of A and B at any time t so that probilities of getting alpha and beta particles are same at that instant?

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23. Half-life of a radioactive sunstance A is two times the half-life of another radioactive substance B Intilally the number of nuclie of A and B are N_A and N_B respectively After three half lives of A number of nuclie of bothe equal. Then the ratio N_A / N_B is

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24. A radioactive sample decays with an average life of $20ms$. A capacitor of capacitance $100\mu F$ is charged to some potential and then the plates are connected through a resistance R. What should be the value of R so that the ratio of the charge on the capacitor to the activity of the radioactive sample remains constant in time?

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25. A charged capacitor of capacitance C is discharged through a resistance $R. A.$ Radiacvtive sample decays with an average life τ. Find the value of R for which the ratio of the electrostatic field energy stored in the capacitor to the activity of the radioactive sample is independent of time.

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26. Nuclei of a radioactive element A are being produced at a constant rate α. The element has a decay constant λ. At time $t = 0$, there are N_0 nuclei of the element.

(a) Calculate the number N of nuclei of A at time t.

(b) If $\alpha = 2N_0\lambda$, calculate the number of nuclei of A after one half-life of A, and also the limiting value of N as $t \to \infty$.

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27. Consider a radioactive disintegration according to the equation $A \to B \to C$. Decay constant of A and B is same and equal to λ. Number of nuclei of A, B and C are N_0 , 0, 0 respectively at $t = 0$. Find

(a) number of nuclei of B as function of time t.

(b) time t at which the activity of B is maximum and the value of maximum activity of B.

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28. The radioactive isotope is being produced at a constant rate A. The isotope has a half-life T. Initially, there are no nuclei, after a time $t > > T$, the number of nuclei becomes constant. The value of this constant is

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29. A radio nuclide with disintegration constant λ is produced in a reactor at a constant rate α nuclei per second. During each decay energy E_0 is released. 20% of this energy is utilized in increasing the temperature of water. Find the increase in temperature of m mass of water in time t. Specific heat of water is s. Assume that there is no loss of energy through water surface.

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