PHYSICS

BOOKS - DC PANDEY PHYSICS (HINGLISH)

MODERN PHYSICS - 2

Example

1. Mass number of a nucleus X is A and atomic number is Z. Find mass number and atomic number of the new nucleus (say Y) after the emission of m-alpha particles and n-beta particles.

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2. 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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3. At time $t=0$, activity of a radioactive substance is 1600 Bq, at t=8 s activity remains 100 Bq. Find the activity at t=2 s.

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4. From a radioactive substance n_1 nuclei decay per second at an instant when total number of nuclei are n_2. Find half-life of the radioactive substance.

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5. Half-life of a radioactive substance is T. At time t_1 activity of a radioactive substance is R_1 and at time t_2 it is R_2. Find the number of nuclei decayed in this interval of time.

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6. Two radioactive X_1 and X_2 have decay constants 10λ and λ respectively . If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2will be $1/e$ after a time .

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7. The half-life period of a radioactive element x is same as the mean life time of another radioactive element y. Initially, both of them have the same number of atoms. Then,

(a) x and y have the same decay rate initially

(b) x and y decay at the same rate always

(c) y will decay at a faster rate than x

(d) x will decay at a faster rate than y

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8. A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life of one species is τ and that of the other is 5τ. The decay products in both cases are stable. A plot is made of the total number of radioactive nuclei as a function of time. Which of the following figure best represents the form of this plot?

(a), (b), (c), (d)

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9. A radio nuclide X is produced at constant rate α. At time $t = 0$, number of nuclei of X are zero. Find

(a) the maximum number of nuclei of X.

the number of nuclei at time t.

Decay constant of X is λ.

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10. In the above problem if each decay produces E_0 energy, then find

(a) power produced at time t

(b) total energy produced upto time t

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11. Find the increase in mass of water when $1.0 kg$ of water absorbs 4.2×10^3 J of energy to produce a temperature rise of $1K$.

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12. In the fusion reaction $_1^2H + _1^2H \rightarrow _2^3He + _0^1n$, the masses of deuteron, helium and neutron expressed in amu are 2.015, 3.017 and 1.009 respectively. If 1 kg of deuterium undergoes complete fusion, find the amount of total energy released. 1 amu $= 931.5 MeV / c^2$.

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13. A nucleus with mass number 220 initially at rest emits an α-particle. If the Q-value of the reaction is 5.5 MeV, 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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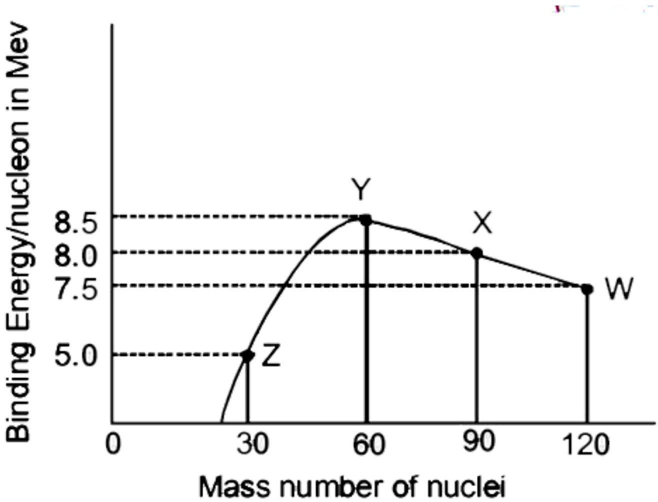
14. Binding energy per nucleons vs mass curve for nucleus is shown in the figure W, X, Y and Z are four nuclei indicated on the curve . The process that would release energy is



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15. A star initially has 10^{40} deuterons. It produces energy via the processes $_1H^2 +_1 H^2 \rightarrow_1 H^3 + p$ and $_1H^2 +_1 H^3 \rightarrow_2 He^4 + n$. If the average power radiated by the star is 10^{16} W, the deuteron supply of the star is exhausted in a time of the order of

(a) $10^6 s$ (b) $10^8 s$ (c) $10^{12} s$

The masses of the nuclei are as follows

$M(H^2) = 2.014$ amu, $M(n) = 1.008$ amu,

$M(p) = 1.007$ amu,$M(He^4) = 4.001$amu

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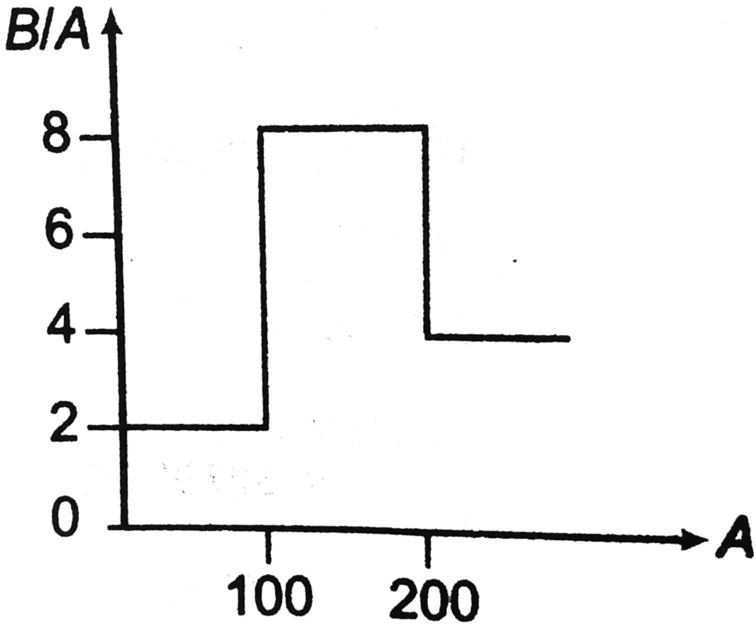
16. Assume that the nuclear binding energy per nucleon (B/A) versus mass number (A) is as shown in figure. Use this plot to choose the correct choice(s) given below.

(a) Fusion of two nuclei with mass numbers, lying in the range of $1 < A < 50$ will release energy.

Fusion of two nuclei with mass numbers lying in the range of $51 < A < 100$ will release energy.

(c) Fission of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken into two equal fragements.

(d) Fission of a nucleus lying in the mass range of $200 < A < 260$ will release energy when broken into two equal fragments.



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Example Type 1

1. At a given instant there are 25% undecayed radioactive nuclei in a sample. After 10 s the number of undecayed nuclei reduces to 12.5%. Calculate

(a) mean life of the nuclei,

(b) the time in which the number of undecayed nuclei will further reduce to 6.25% of the reduced number.

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

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3. A small quantity of solution containing Na^{24} radio nuclide (half-life=15 h) of activity 1.0 microcurie is injected into the blood of a person. A sample of the blood of volume $1cm^3$ taken after 5h shows an activity of 296 disintegrations per minute. Determine the total volume of the blood in the body of the person. Assume that the radioactive solution mixes uniformly in the blood of person.

(1 curie $= 3.7 \times 10^{10}$ disintegrations per second)

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4. A radioactive nucleus X decays to a nucleus Y with a decay constant $\lambda_X = 0.1 s^{-1}$, Y further decays to a stable nucleus Z with a decay constant

$\lambda_Y = 1/30 s^{-1}$. Initially, there are only X nuclei and their number is $N_0 = 10^{20}$. Set up the rate equations for the populations of X, Y and Z. The population of Y nucleus as a function of time is given by $N_Y(t) = \{N_0 \lambda_X / (\lambda_X - \lambda_Y)\}[\exp(-\lambda_Y t) - \exp(-\lambda_X t)]$.

Find the time at which N_Y is maximum and determine the population X and Z at that instant.

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Example Type 2

1. In a nuclear reactor $\hat{} 235U$ undergoes fission liberating 200 MeV of energy. The reactor has a 10% efficiency and produces 1000 MW power. If the reactor is to function for 10 yr, find the total mass of uranium required.

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

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3. A nucleus X, initially at rest, undergoes alpha-decay according to the equation.

$_92^A X \to_Z^{228} Y + \alpha$

(a) Find the values of A and Z in the above process.

(b) The alpha particle produced in the above process is found in move in a circular track of during the process and the binding energy of the parent nucleus X.

Given that $m(Y) = 228.03u, m($_0^1n)=1.009um($_2^4 He) = 4.003u, m($ _1^1H)=1.008u`

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

$_1^2 H +_1^2 H \to_2^4 He$

in a nuclear reactor 200 MW 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 `_2^4He are 2.0141 atommic mass units and 4.0026 atomic mass units respectively.)

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Miscellaneous Examples

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

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2. Neon-23 decays in the following way,

$$\_\ 10^{23}Ne \to^{23}_{11} Na +^{0}_{-1} e + \bar{v}$$

Find the minimum and maximum kinetic energy that the beta particle $\left(\_\ (-1)^{0}e\right)$ can have. The atomic masses of $\hat{\ } 23Ne$ and $\hat{\ } 23Na$ are $22.9945u$ and $22.9898u$, respectively.

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3. The mean lives of an unstable nucleus in two different decay processes are 1620 yr and 405 yr, respectively. Find out the time during which three-fourth of a sample will decay.

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4. In the chemical analysis of a rock the mass ratio of two radioactive isotopes is found to be $100:1$. The mean lives of the two isotopes are 4×10^9 years and 2×10^9 years, respectively. If it is assumed that at the time of formation the atoms of both the isotopes were in equal propotional, calculate the age of the rock. Ratio of the atomic weights of the two isotopes is $1.02:1$.

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5. A proton is bombarded on a stationary lithium nucleus. As a result of the collision, two α-particles are produced. If the direction of motion of the α-particles with the initial direction of motion makes an angles $\cos^{-1}(1/4)$, find the kinetic energy of the striking proton. Given, binding energies per nucleon of Li^7 and He^4 are 5.60 and 7.06 MeV, respectively. (Assume mass of proton $\approx$ mass of neutron).

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6. A $\hat{\ } 7Li$ target is bombarded with a proton beam current of 10^{-4} A for 1 hour to produce $\hat{\ } Be$ of activity 1.8×10^8 disintegrations per second. Assuming that $\hat{\ } 7Be$ radioactive nucleus is produced by bombarding 1000 protons, determine its half-life.

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

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

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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8. Natural uranium is a mixture of three isotopes $\_92^{234}U$, $\_92^{234}U$, $\_92^{235}U$ and $\_92^{238}U$ with mass percentage 0.01%, 0.71% and 99.28% respectively. The half-life of three isotopes are $2.5 \times 10^5 yr$, $7.1 \times 10^8 yr$ and $4.5 \times 10^9 yr$ respectively.

Determine the share of radioactivity of each isotope into the total activity of the natural uranium.

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9. Uranium ores on the earth at the present time typically have a composition consisting of 99.3% of the isotope $\_92U^{238}$ and 0.7% of the isotope $\_92U^{235}$. The half-lives of these isotopes are $4.47 \times 10^9 yr$ and

$7.04 \times 10^8 yr$, respectively. If these isotopes were equally abundant when the earth was formed, estimate the age of the earth.

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Exercise 34 1

1. The decay constant of a radioactive sample is λ. The half-life and the average-life of the sample are respectively

A. (a) $1/\lambda$ and $(In2)/\lambda$

B. (b) $(In2)/\lambda$ and $1/\lambda$

C. (c) $\lambda(In2)$ and $1/\lambda$

D. $\lambda/(In2)$ and $1/\lambda$

Answer: B

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2. Consider a particle , β particle and $\gamma - rays$, each having an energy of $0.5 MeV$. In increase order of panetrating power , the radiation are .

A. (a) α, β, γ

B. (b) α, γ, β

C. (c) β, γ, α

D. (d) γ, β, α

Answer: A

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3. Which of the following is a correct statement?

A. (a) Beta rays are same as cathode rays

B. (b) Gamma rays are high energy neutrons

C. (c) Alpha particles are singly ionized helium atoms

D. (d) Protons and neutrons have exactly the same mass

Answer: A

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4. The electron emitted in beta radiation originates from

A. (a) inner orbits of atom

B. (b) free electrons existing in nuclei

C. (c) decay of a neutron in a nucleus

D. (d) photon escaping from the nucleus

Answer: C

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5. During a negative beta decay,

A. (a) an atomic electron is ejected

B. (b) an electron which is already present within the nucleus is ejected

C. (c) a neutron in the nucleus decays emitting an electron

D. (d) a part of the binding energy of the nucleus is converted into a electron

Answer: C

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6. A freshly prepared radioactive source of half-life $2h$ emits radiation of intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely with this source is

A. 6h

B. 12h

C. 24h

D. 128 h

Answer: B

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7. A radioactive sample S_1 having an activity of $5 \mu Ci$ has twice the number of nuclei as another sample S_2 which has an activity of $10 \mu Ci$. The half-lives of S_1 and S_2 can be

A. (a) 20 yr and 5 yr, respectively

B. (b) 20 yr and 10 yr, respectively

C. (c) 10 yr each

D. (d) 5 yr each

Answer: A

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

A. (a) 1/4

B. (b) 3/4

C. (c) 1/2

D. (d) 1

Answer: B

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9. 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

A. (a) 6000

B. (b) 9000

C. (c) 3000

D. (d) 24000

Answer: D

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10. The half-life of $\hat{\ } 215At$ is $100\mu s$. The time taken for the activity of a sample of $\hat{\ } 215At$ to decay to $\frac{1}{16}th$ of its initial value is

A. $400\mu s$

B. $63\mu s$

C. $40\mu s$

D. $300\mu s$

Answer: A

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11. The half life of radioactive Radon is $3.8 days$. The time at the end of which $\frac{1}{20}th$ of the radon sample will remain undecayed is $(given \log e = 0.4343)$

A. (a) 3.8 days

B. (b) 16.5 days

C. (c) 33 days

D. (d) 76 days

Answer: B

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12. Activity of a radioactive substance decreases from 8000 Bq to 1000 Bq in 9 days. What is the half-life and average life of the radioactive substance?

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13. A radioactive substance has a half-life of 64.8 h. A sample containing this isotope has an initial activity $(t = 0)$ of $40 \mu Ci$. Calculate the number of nuclei that decay in the time interval between $t_1 = 10.0h$ and $t_2 = 12.0h$.

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

(a) Find the decay constant and half-life

How many atoms of the isotope were contained in the freshly preapared sample?

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

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15. 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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16. 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 $N_X I N_Y$ after 200 minutes.

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Exercise 34 2

1. 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)

A. (a) 7.6 MeV

B. (b) 56.12 MeV

C. (c) 10.24 MeV

D. (d) 23.4 MeV

Answer: C

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2. Fast neutrons can easily be slowed down by

A. (a) the use of lead shielding

B. (b) passing them through heavy wate

C. (c) elastic collisions with heavy nuclei

D. (d) applying a strong electric field

Answer: B

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3. During a nuclear fusion reaction,

A. (a) a heavy nucleus breaks into two fragements by itself

B. (b) a light nucleus bombarded by thermal neutrons breaks up

C. (c) a heavy nucleus bombarded by thermal neutrons breaks up

D. (d) two light nuclei combine to give a heavier nucleus and possibly other products

Answer: D

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4. The equation

$4H^{+} \rightarrow_{2}^{4} He^{2+} + 2e \overline{+} 26 MeV represents$

A. (a) β-decay

B. (b) γ-decay

C. (c) fusion

D. (d) fission

Answer: C

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5. (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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6. Find energy released in the alpha decay,

Given $\_\ 92^{238}U \rightarrow^{234}_{90} Th +^{4}_{2} He$

$M($_92^238U)=238.050784uM($\_\ 90^{234}Th) = 234.043593u$

$M($_2^4He)=4.002602u`

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7. Complete the nuclear reactions.

(a) $\_3^6Li + ? \rightarrow_4^7 Be +_0^1 n$ (b) $\_17^{35}CI + ? \rightarrow_{16}^{32} S +$ _2^4He(c) _4^9Be+_2^4Herarr3$(_2^4He) + ?$ (d) $_35^{79}Br +_2^1 H \rightarrow ? + 2($_0^1n)`

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8. Consider the reaction $\_1^2H +_1^2 H =_2^4 He + Q$. Mass of the deuterium atom $= 2.0141u$. Mass of helium atom $= 4.0024u$. This is a nuclear.........reaction in which the energy Q released is............MeV.

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9. The binding energies per nucleon for deuteron ($\_1H^2$) and helium ($\_2He^4) are 1.1MeV$ and $7.0MeV respectively. The e \neq rgy re \leq ased whe$

_2He^4`) is........

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Assertion And Reason

1. Assertion : Rate of radioactivity cannot be increased or decreased by increasing or decreasing pressure or temperature.

Reason : Rate depends on the number of nuclei present in the radioactive sample.

A. If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: B

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2. Assertion : Only those nuclei which are heavier than lead are radioactive.

Reason : Nuclei of elements heavier than lead are unstable.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

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3. Assertion : After emission of one α-particle and two β-particles, atomic number remains unchanged.

Reason : Mass number changes by four.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: B

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4. Assertion : γ-rays are produced by the transition of a nucleus from some higher energy state to some lower energy state.

Reason : Electromagnetic waves are always produced by the transition process.

A. If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: C

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5. Assertion : During β-decay a proton converts into a neutron and an electron. No other particle is emitted.

Reason: During β-decay linear momentum of system should remain constant.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

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6. Assertion : If we compare the stability of two nuclei, then that nucleus is more stable whose total binding energy is more.

Reason: More the mass defect during formation of a nucleus more will be the binding energy.

A. If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true, but the Reason is false.

D. If Assertion is false but the Reason is true.

Answer: D

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7. Assertion : In a nuclear process energy is released if total binding energy of daughter nuclei is more than the total binding energy of parent nuclei.

Reason: If energy is released then total mass of daughter nuclei is less than the total mass of parent nuclei.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: A::B

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8. Assertion : Binding energy per nucleon is of the order of MeV.

Reason: $1MeV = 1.6 \times 10^{-13}J$.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: B

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9. Assertion : 1 amu is equal to 931.48 MeV.

Reason: 1 amu is equal to 1/12th the mass of C^{12} atom.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: D

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10. Assertion: Between α, β and γ radiations, penetrating power of γ-rays is maximum.

Reason : Ionising power of γ-rays is least.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: B

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11. Assertion: The nuclear energy can be obtained by the nuclear fission of heavier nuclei as well as by fusion of lighter nuclei.

Reason: As the mass number increases, the binding energy per nucleon, first increases and then decreases.

A. (a) If both Assertion and Reason are true and Reason is correct explanation of the Assertion.

B. (b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. (c) If Assertion is true, but the Reason is false.

D. (d) If Assertion is false but the Reason is true.

Answer: A::B

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Level 1 Objective

1. For uranium nucleus how does its mass vary with volume?

A. (a) $m \propto V$

B. (b) $m \propto 1/V$

C. (c) $m \propto \sqrt{V}$

D. (d) $m \propto V^2$

Answer: A

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2. Order of magnitude of density of uranium nucleus is , [m = 1.67 xx 10^(-27 kg]`

A. (a) $10^{20} kg / m^3$

B. (b) $10^{17} kg / m^3$

C. (c) $10^{14} kg / m^3$

D. (d) $10^{11} kg / m^3$

Answer: B

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3. During a beta decay

A. (a) an atomic electron is ejected

B. (b) an electron present inside the nucleus is ejected

C. (c) a neutron in the nucleus decays emitting and electron

D. (d) a part of the binding energy is converted into electron

Answer: C

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4. In the nucleus of helium if $F_1 isthe \ne tf$ or $cebetweentwopro \to ns$, F_2$isthe \ne tf$ or $cebetweentwo \ne utrons$ and F_3` is the net force between a proton and a neutron. Then,

A. (a) $F_1 = F_2 = F_3$

B. (b) $F_1 > F_2 > F_3$

C. (c) $F_2 > F_3 > F_1$

D. (d) $F_2 = F_3 > F_1$

Answer: A

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5. What are the respective number of α and β-particles emitted in the following radioactive decay?

A. (a) 6 and 8

B. (b) 6 and 6

C. (c) 8 and 8

D. (d) 8 and 6

Answer: D

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6. If an atom of $\_92^{235}U$, after absorbing a slow neutron, undergoes fission to form an atom of $-54^{138}Xe$ and an atom of $\_38^{94}Sr$, the other particles produced are

A. (a) one proton and two neutrons

B. (b) three neutrons

C. (c) two neutrons

D. (d) one proton and one neutron

Answer: B

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7. Nucleus A is converted into C through the following reactions,

$A \rightarrow B + \alpha$

$B \rightarrow C + 2\beta$

then,

A. (a) A and B are isotopes

B. (b) A and C are isobars

C. (c) A and B are isobars

D. (d) A and C are isotopes

Answer: D

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8. The binding energy of α-particle is

(if $m_p = 1.00785u, m_n = 1.00866u$ and $m_\alpha = 4.00274u$)

A. (a) 56.42 MeV

B. (b) 2.821 MeV

C. (c) 28.21 MeV

D. (d) 32.4 MeV

Answer: C

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9. $\frac{7}{8}th$ of the active nuclei present in a radioactive sample has decayed in 8 s. The half-life of the sample is

A. (a) 2s

B. (b) 1s

C. (c) 7s

D. (d) 8/3 s

Answer: D

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10. A radioactive element disintegrates for a time interval equal to its mean life. The fraction that has disintegrated is

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

B. $1-\frac{1}{e}$

C. $\frac{0.693}{e}$

D. $0.693\left(1-\frac{1}{e}\right)$

Answer: B

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11. Starting with a sample of pure $\hat{} 66Cu, \frac{3}{4}$ of it decays into Zn in 15 minutes. The corresponding half-life is

A. (a) 5 minutes

B. (b) 7.5 minutes

C. (c) 10 minutes

D. (d) 3.5 minutes

Answer: B

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12. A sample of radioactive substance loses half of its activity in 4 days. The time in which its activity is reduced to 5% is

A. (a) 12 days

B. (b) 8.3 days

C. (c) 17.3 days

D. (d) None of these

Answer: C

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13. On bombardment of U^{235} by slow neutrons, 200 MeV energy is released. If the power output of atomic reactor is 1.6 MW, then the rate of fission will be

A. (a) 5×10^{16} per second

B. (b) 10×10^{16} per second

C. (c) 15×10^{16} per second

D. (d) 20×10^{16} per second

Answer: A

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14. Atomic masses of two heavy atoms are A_1 and A_2. Ratio of their respective nuclear densities will be approximately

A. (a) $\frac{A_1}{A_2}$

B. (b) $\left(\frac{A_1}{A_2}\right)^{\frac{1}{3}}$

C. (c) $\left(\frac{A_2}{A_1}\right)^{\frac{1}{3}}$

D. (d) 1

Answer: D

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15. A radioactive element is disintegrating having half-life 6.93 s. The fractional change in number of nuclei of the radioactive element during 10 s is

A. (a) 0.37

B. (b) 0.63

C. (c) 0.25

D. (d) 0.50

Answer: B

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16. The activity of a radioactive sample goes down to about 6% in a time of 2 hour. The half-life of the sample in minute is about

A. (a) 30

B. (b) 15

C. (c) 60

D. (d) 120

Answer: A

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

A. (a) $\frac{1}{e}$

B. (b) $\frac{1}{e+1}$

C. (c) $1-\frac{1}{e}$

D. (d) $\frac{1}{e}-1$

Answer: A

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Level 1 Subjective

1. 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

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2. A radioactive sample contains 1.00×10^{15} atoms and has an activity of 6.00×10^{11} Bq. What is its half-life?

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

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4. The half-life of $\_92^{238}U$ against alpha decay is 4.5×10^{9} year. How much disintegration per second occurs in 1 g of $\_92^{238}U$?

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

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6. In an ore containing uranium, the ratio of ^238U $\to$ 206Pb $\nu c \le iis3. Calc\underline{a}tethea \ge ofthe$ or $e, as \sum \in gt\hat{a}llthe \le adpresent \in t$ ^238U. $Takethehalf - l$ if eof^238U $\to be$4.5xx10^9` years.

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7. Complete the following reactions.

(a) $\_88^{226}Ra \rightarrow \alpha +$ (b) $\_8^{19}O \rightarrow^{19}_{9} F +$ (c) $\_13^{25}AI \rightarrow^{25}_{12} Mg +$

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8. Consider two decay reactions.

(a) $\_92^{236}U \rightarrow^{206}_{82} Pb + 10pro \rightarrow ns + 20 \neq utrons$ (b) $\_92^{238}U \rightarrow^{206}_{83} Pb + 8^4_2He + 6e \leq ctrons$

Are both the reactions possible?

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9. Obtain the binding energy of a nitrogen nucleus from the following data:

$m_H = 1.00783u$,m_N=1.00867u, $m($_7^14N)=14.00307u

$Giveyouranswer \in unitsofMeV. [Remember$1u=931.5MeV//c^2`]

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10. 8 protons and 8 lectures are separately at rest. How much energy will be released if we form $\_8^{16}O$ nucleus?

Given:

Mass of $\_8^{16}O$ atom = 15.994915u

Mass of neutron =1.008665u

Mass of hydrogen atom = 1.007825u

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11. Assuming the splitting of U^{235} nucleus liberates 200 MeV 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 1 kg of U^{235}.

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12. $\_83^{212}Bi$ decays as per following equation.

$\_83^{212}Bi \rightarrow_{82}^{208} Ti +_2^4 He$

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

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13. In a neutron induced fission of $\_92U^{235}$ nucleus, usable energy of 185 MeV is released. If $\_92U^{235}$ reactor is continuously operating it at a power level of 100 MW power, how long will it take for 1 kg of uranium to be consumed in this reactor?

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14. Calculate the Q-values of the following fusion reactions:

(a)$1^2H + 1^2H \rightarrow 1^3H + 1^1H.$

$1^2H + 1^2H \rightarrow 2^3(He) + n$

$1^2H + 1^3H \rightarrow 2^4(He) + n.$

Atomic masses are $m(1^2H) = 2.014102u$, $m(1^3H) = 3.016049u$, $m(2^3(He)) = 3.016029u, m(2^4(He)) = 4.002603u.$

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15. Calculate the Q-values of the fusion reaction

$He^4 + He^4 = Be^8$

In such a fusion energetically favourable? Atomic mass of Be^8 is 8.0053u and that of $He^4$is 4.0026 u.

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16. When fission occurs, several neutrons are released are released and the fission fragements are beta radioactive, why?

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Level 1 Subjective Questions

1. The half-lives of radioisotopes P^{32} and P^{33} are 14 days and 25 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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Level 2 Single Correct

1. The count rate observed from a radioactive source at t second was N_0 and at 4t second it was $\frac{N_0}{16}$. The count rate observed at $\left(\frac{11}{2}\right)t$ second will be

A. $\frac{N_0}{128}$

B. $\frac{N_0}{64}$

C. $\frac{N_0}{32}$

D. None of these

Answer: B

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2. The half-lives of radioactive sample are 30 years and 60 years for two decay processes. If the sample decays by both the processes simultaneously. The time after which, only one-fourth of the sample will remain is

A. 10 years

B. 20 years

C. 40 years

D. 60 years

Answer: C

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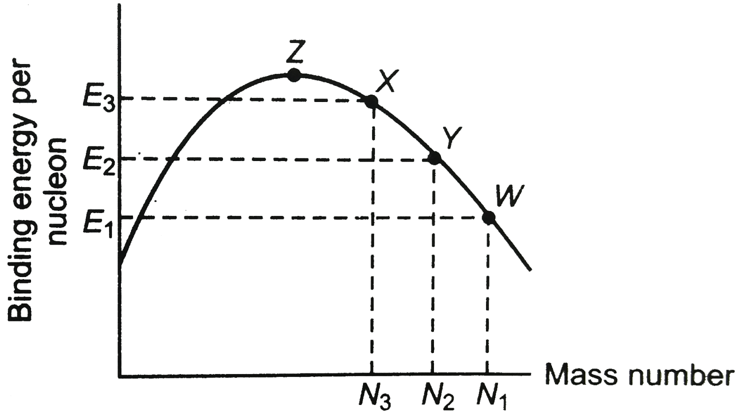
3. Consider the nuclear fission reaction $W \rightarrow X + Y$. What is the Q-value (energy released) of the reaction?



A. $E_1N_1 - (E_2N_2 + E_3N_3)$

B. $(E_2N_2 + E_3N_3 - E_1N_1)$

C. $E_2N_2 + E_1N_1 - E_3N_3$

D. $E_1N_1 + E_3N_3 - E_2N_2$

Answer: B

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4. Consider the following nuclear reaction,

$X^{200} \rightarrow A^{110} + B^{90} + Energy$

If the binding energy per nucleon for X, A and B are 7.4 MeV, 8.2 MeV and 8.2 MeV respectively, the energy released will be

A. 900 MeV

B. 110 MeV

C. 200 MeV

D. 160 MeV

Answer: D

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5. The energy released by the fission of a single uranium nucleus is 200 MeV. The number of fission of uranium nucleus per second required to produce 16 MW of power is (Assume efficiency of the reactor is 50%)

A. (a) 2×10^6

B. (b) 2.5×10^6

C. (c) 5×10^6

D. (d) None of these

Answer: D

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6. A radioactive isotope is being produced at a constant rate $dN/dt = R$ in an experiment. The isotope has a half-life $t_{1/2}$.Show that after a time $t > > t_{1/2}$,the number of active nuclei will become constant. Find the value of this constant.

A. RT

B. $\frac{R}{T} 1n2$

C. $RT1n2$

D. $\frac{RT}{1n2}$

Answer: D

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7. A bone containing 200 g carbon-14 has β-decay rate of 375 decay/min. Calculate the time that has elapsed since the death of the living one. Given the rate of decay for the living organism is equal to 15 decay per min per gram of carbon and half-life of carbon-14 is 5730 years.

A. (a) 27190 years

B. (b) 1190 years

C. (c) 17190 years

D. (d) None of these

Answer: C

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8. Two identical samples (same material and same amount) P and Q of a radioactive substance having mean life T are observed to have activities A_P and A_Q respectively at the time of observation. If P is older than Q, then the difference in their age is

A. $T 1 n\left(\frac{A_P}{A_Q}\right)$

B. $T 1 n\left(\frac{A_Q}{A_P}\right)$

C. $T\left(\frac{A_P}{A_Q}\right)$

D. $T\left(\frac{A_Q}{A_P}\right)$

Answer: B

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9. A star initially has 10^{40} deuterons. It produces energy via the processes $_1^2 H+_1^2 H \rightarrow_1^3 H+p$ and $_1^2 H+_1^3 H \rightarrow_2^4 He+n$. Where the masses of the nuclei are

$m($^2H)=2.014$a\mu$, m(p)=1.007$a\mu$, m(n)=1.008$a\mu$ and m($\hat{}$ $4He)=4.001$ amu. If the average power radiated by the star is $10^{16} W$, the deuteron supply of the star is exhausted in a time of the order of

A. (a) $10^6 s$

B. (b) $10^8 s$

C. (c) $10^{12}s$

D. (d) $10^{16}s$

Answer: C

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10. Two radioactive samples of different elements (half-lives t_1 and t_2 respectively) have same number of nuclei at $t=0$. The time after which their activities are same is

A. $\frac{t_1 t_2}{0.693(t_2 - t_1)} 1n \frac{t_2}{t_1}$

B. $\frac{t_1 t_2}{0.693} 1n \frac{t_2}{t_1}$

C. $\frac{t_1 t_2}{0.693(t_1 + t_2)} 1n \frac{t_2}{t_1}$

D. None of these

Answer: A

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11. A nucleus X initially at rest, undergoes alpha decay according to the equation

$$_{-}Z^{232}X \rightarrow ^{A}_{90} Y + \alpha$$

What fraction of the total energy released in the decay will be the kinetic energy of the alpha particle?

A. (a) $\frac{90}{92}$

B. (b) $\frac{228}{232}$

C. (c) $\sqrt{\frac{228}{232}}$

D. (d) $\frac{1}{2}$

Answer: B

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12. A stationary nucleus of mass 24 amu emits a gamma photon. The energy of the emitted photon is 7 MeV. The recoil energy of the nucleus is

A. (a) $2.2keV$

B. (b) $1.1keV$

C. (c) $3.1keV$

D. (d) $2.2keV$

Answer: B

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13. 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

A. $\frac{T}{1n2}1n\frac{2A_1}{A_2}$

B. $T1n\frac{A_1}{A_2}$

C. $\frac{T}{1n2}1n\frac{A_2}{2A_1}$

D. $T1n\frac{A_2}{2A_1}$

Answer: C

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Level 2 More Than One Correct

1. At $t = 0$, number of radioactive nuclei of a radioactive substance are x and its radioactivity is y. Half-life of radioactive substance is T. Then,

A. (a) $\frac{x}{y}$ is constant throughout

B. (b) $\frac{x}{y} > T$

C. (c) value of xy remains half after one half-life

D. (d) value of xy remains one fourth after one half-life

Answer: A::B::D

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2. Choose the correct options.

A. (a) Isotopes have same number of atomic number

B. (b) Isobars have same atomic weight

C. (c) Isotones have same number of neutrons

D. (d) In neutral isotope atoms number of electrons are same

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

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3. Choose the correct options.

A. (a) By gamma radiations atomic number is not changed

B. (b) By gamma radiations mass number is not changed

C. (c) By the emission of one α and two β particles isotopes are produced

D. (d) By the emission of one α and four β particles isobars are produced

Answer: A::B::C

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4. Two radioactive substances have half-lives T and 2T. Initially, they have equal number of nuclei. After time $t = 4T$, the ratio of their number of nuclei is x and the ratio of their activity is y. Then,

A. (a) $x = 1/8$

B. (b) $x = 1/4$

C. (c) $y = 1/2$

D. (d) $y = 1/4$

Answer: B::C

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5. Regarding the nuclear forces, choose the correct options.

A. (a) They are short range forces

B. (b) They are charge independent forces

C. (c) They are not electromagnetic forces

D. (d) They are exchange forces

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

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6. Regarding a nucleus choose the correct options.

A. (a) Density of a nucleus is directly proportional to mass number A

B. (b) Density of all the nuclei is almost constant of the order of $10^{17} kg / m^3$

C. (c) Nucleus radius is of the order of $10^{-15} m$

D. (d) Nucleus radius $\propto$ A

Answer: B::C

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Level 2 Comprehension Based

1. The atomic masses of the hydrogen isotopes are

Hydrogen $m_1H^1 = 1.007825$ amu

Deuterium $m_1H^2 = 2.014102$ amu

Tritium $m_1H^3 = 3.016049$ amu

The energy released in the reaction,

$\_1H^2 +_1 H^2 \rightarrow_1 H^3 +_1 H^1$ is nearly

A. (a) 1MeV

B. (b) 2MeV

C. (c) 4MeV

D. (d) 8 MeV

Answer: C

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2. The atomic masses of the hydrogen isotopes are

Hydrogen $m_1 H^1 = 1.007825$ amu

Deuterium $m_1 H^2 = 2.014102$ amu

Tritium $m_1 H^3 = 3.016049$ amu

The number of fusion reactions required to generate 1kWh is nearly

A. (a) 10^8

B. (b) 10^{18}

C. (c) 10^{28}

D. (d) 10^{38}

Answer: B

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3. The atomic masses of the hydrogen isotopes are

Hydrogen $m_1H^1 = 1.007825$ amu

Deuterium $m_1H^2 = 2.014102$ amu

Tritium $m_1H^3 = 3.016049$ amu

The mass of deuterium, $\_1H^2$ that would be needed to generate 1 kWh

A. (a) $3.7kg$

B. (b) $3.7g$

C. (c) $3.7 \times 10^{-5}kg$

D. (d) $3.7 \times 10^{-8}kg$

Answer: D

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Level 2 Subjective

1. 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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2. 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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3. 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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4. A solution contains a mixture of two isotopes A (half-life=10days) and B (half-life=5days). Total activity of the mixture is 10^{10} disintegration per second at time $t = 0$. The activity reduces to 20% in 20 days. Find (a) the initial activities of A and B, (b) the ratio of initial number of their nuclei.

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5. 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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6. A stable nuclei C is formed from two radioactive nuclei A and B with decay constant of λ_1 and λ_2 respectively. Initially, the number of nuclei of A is N_0 and that of B is zero. Nuclei B are produced at a constant rate of P. Find the number of the nuclei of C after time t.

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7. Polonium $(_ 84^{210}$Po$)emits$_2^4He $partic \leq s$ and $isconverted \int o \leq ad($_82^206Pb $). Thisreactionisusedf$ or $\prod uc \in ge \leq ctricpower \in aspacemission.$

Po^210

$hashalf - l$ if $eof138.6days. As \sum \in ganefficiencyof10\% f$ or $theth$

^210Po$isrequired \to \prod uce$1.2xx10^7J

$ofe \leq ctrice \neq rgyperdayattheendof693days. Alsof \in dthe \in itialactivi$

^210Po=209.98264$a\mu$, ^206Pb=205.97440$a\mu$, _2^4He=4.00260$a\mu$, 1 am

u=931 MeV//c^2 and $Avogadro' s\nu mber$ = 6xx10^23//mol`

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8. A radio nuclide consists of two isotopes. One of the isotopes decays by α-emission and other by β-emission with half-lives $T_1 = 405s$ and $T_2 = 1620s$, respectively. At $t = 0$, probabilities of getting α and β-particles from the radio nuclide are equal . Calculate their respective probabilities at $t = 1620s$. If at $t = 0$, total number of nuclei in the radio nuclide are N_0. Calculate the time t when total number of nuclei remained undecayed becomes equal to $N_0 / 2$.

$\log_{10} 2 = 0.3010, \log_{10} 5.94 = 0.7742$ and $x^4 + 4x - 2.5 = 0$, x=0.594`

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9. Find the amount of heat generated by 1 mg of Po^{210} preparation during the mean life period of these nuclei if the emitted alpha particles are known to possess kinetic energy 5.3 MeV and practically all daughter nuclei are formed directly in the ground state.

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10. In an agriculture experiment, a solution containing 1 mole of a radioactive meterial $\left(t_{1/2} = 14.3 days\right)$ was injected into the roots of a plants.the plant was allowed 70 hours to settle down and then activity eas measured in its fruit. If the activity measured was $1 \mu Ci$ what per cent of activity is transmitted from the root to the fruit in steady state?

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