CPP-10
SS JEE(M) &
ADVANCED

Physics

Chapterwise Practise Problems (CPP) for JEE (Main & Advanced)

Chapter - Nuclei

Level-1

SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. In a hypothetical nuclear fission event, the original nucleus (binding energy 6 MeV/nucleon) has 200 nucleons and splits into two nuclei each with 100 nucleons (binding energy 6.2 MeV/nucleon). The total energy released in the fission of one nucleus is

   (A) 40 MeV (B) 20 MeV
   (C) 0.4 MeV (D) 0.2 MeV

2. The activity of a sample of radioactive material is eA at time e and A at the time 2e. The mean life of sample is

   (A) 1 (B) 2
   (C) e (D) 2e

3. Nuclei of a radioactive element X are being produced at a constant rate q and this element decays to a stable nucleus Y with decay constant λ and half-life $T_{1/2}$. At time t = 0, there are N_0 nuclei of the element X. Find the number N_x of nuclei of X at time $t = T_{1/2}$.

   (A) $\frac{q+\lambda N_0}{2\lambda}$ (B) $(2\lambda N_0 - q)\frac{1}{\lambda}$
   (C) $\left(\lambda N_0 + \frac{q}{2}\right)\frac{1}{\lambda}$ (D) $\left[\lambda N_0 - \frac{q}{2}\right]\frac{1}{\lambda}$

4. A radioactive nucleus can decay by three different processes simultaneously. The half life for the processes are 1h, $\frac{1}{\sqrt{2}}$h, $\frac{1}{2}$h. The effective half life of the nucleus is

   (A) $\left(1+\frac{1}{\sqrt{2}}+\frac{1}{2}\right)$hour
   (B) $\left(\frac{3-\sqrt{2}}{7}\right)$hour
   (C) $\frac{1}{2\sqrt{2}}$ hour
   (D) $\frac{3+\sqrt{2}}{7}$ hour

5. A free nucleus of mass 24 amu, initially at rest emits gamma photon. The energy of a photon is 7 MeV. The kinetic energy of recoiling nucleus is approximately equal to [Take : 1 amu = 931 MeV]

   (A) 1.1 keV (B) 2.25 keV
   (C) 3.3 keV (D) 4.4 keV

6. In solar radiation the intensity of radiation is maximum around the wavelength λ. If R is the radius of sun and c is the velocity of light, the mass lost by the sun per unit time is proportional to

   (A) $\frac{R^2}{\lambda^4}$ (B) $\frac{R^2}{\lambda^2}$
   (C) $\frac{R^3}{\lambda^4}$ (D) $\frac{R^3}{\lambda^4}$

7. During negative β decay, an anti-neutrino is also emitted along with the ejected electron. Then

   (A) Only linear momentum will be conserved
   (B) Total linear momentum and total angular momentum but not total energy will be conserved
   (C) Total linear momentum and total energy but not total angular momentum will be conserved
   (D) Total linear momentum, total angular momentum and total energy will be conserved

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

8. In a radioactive decay rection:

$$A \xrightarrow[2\lambda]{} B \xrightarrow[9\lambda]{} C$$

If the sample has only A initially, then select correct alternative(s) at the instant the number of the particles of B is maximum :

(A) Activity of A is equal to activity of B

(B) No of atoms of A is 4.5 times of B

(C) Activity of A is more than activity of B

(D) Activity of A is minimum

SECTION - C

Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/ are correct.

Paragraph for Question Nos. 7 and 8

Consider the following nuclear decay :

$$^{236}_{92}U \rightarrow ^{232}_{90}Th + X$$

9. If the uranium nucleus is at rest before its decay, which one of the following statement is true concerning the final nuclei ?

(A) They have equal kinetic energies, but the thorium nucleus has much more momentum

(B) They have equal kinetic energies and momenta are of equal magnitude

(C) They have momentum of equal magnitude, but the thorium nucleus has much more kinetic energy

(D) They have momentum of equal magnitude, but X has much more kinetic energy

10. Following atomic masses and conversion factor are provided

$^{236}_{92}U = 236.045562$ u ; $^{232}_{90}Th = 232.038054$ u ;

$^{1}_{0}n = 1.008665$ u ; $^{1}_{1}p = 1.007277$ u ;

$^{4}_{2}He = 4.002603$ u and 1u = 1.5×10^{-10} J/c^2

The amount of energy released in the decay of U^{236} into Th^{232} is equal to :

(A) 3.5×10^{-8} J

(B) 4.6×10^{-12} J

(C) 6.0×10^{-10} J

(D) 7.4×10^{-13} J

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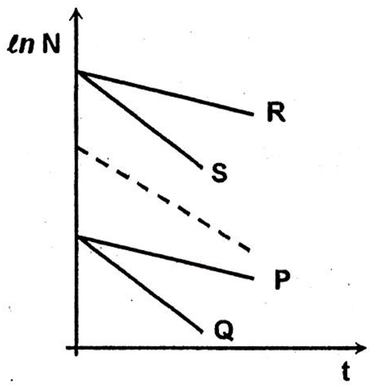
SECTION - A

Straight Objective Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

1. There are two radio active substances A and B whose disintegration constants are λ_A and λ_B respectively. At t = 0 the number of radioactive nuclei of A is N_{A0} and that of B is N_{B0}. It is known that $\lambda_A > \lambda_B$ and $N_{A0} < N_{B0}$. The broken line shows the variation of ln (N_A) with respect to time for substance A. The graph of variation of ln (N_B) with respect to time t will be



(A) P (B) Q
(C) R (D) S

2. A star consist of deuterons. It initially has 10^{40} deutrons. It produces energy by the processes

$${}_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + p$$

$${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + n$$

If the average power radiated by the star is 1.6×10^{16} watt and masses of nuclei are

$M({}_1H^2)$ = 3AMU, M(P)=M(n)=1 AMU, $M({}_2He^4)$=4 AMU and use approximation, energy equivalent to 1AMU = 1000 MeV. Find the time in which the supply of deuteron in the star is exhausted

(A) 10^{10} s (B) 10^{12} s
(C) 10^{14} s (D) 10^{16} s

3. An isolated nucleus wich was initially at rest, disintegrates into two nuclei due to internal nuclear forces and no γ rays are produced. If the ratio of their kinetic energy is found to be $\frac{64}{27}$ then

(A) Ratio of their respective de Broglie wavelength is $\frac{\sqrt{64}}{\sqrt{27}}$

(B) Ratio of their respective speed is $\frac{64}{37}$

(C) Ratio of their respective nuclear radius is $\frac{3}{4}$

(D) Ratio of their respective nuclear radius is $\frac{4}{3}$

4. There are n number of radioactive nuclei in a sample that undergoes beta decay. If from the sample, n' number of β particles are emitted in first 2 seconds, then half life of nuclei (in seconds) is

(A) $\dfrac{2\times0.693}{\ell n\left(\frac{n-n'}{n}\right)}$ (B) $\dfrac{2\times0.693}{\ell n\left(\frac{n-n'}{n'}\right)}$

(C) $0.693\,\ell n(2n/n')$ (D) $\dfrac{2\times0.693}{\ln\left(\frac{n}{n-n'}\right)}$

5. Radioactive isotopes X and Y have half lives of 4 days and 16 days respectively. The total activity of their mixture is 1 curie at certain time. The activity reduces by 50% in 8 days. The ratio (N_x/N_y) of their initial number of atoms is

(A) $\dfrac{2}{\sqrt{2}-1}$ (B) $\dfrac{\sqrt{2}-1}{2}$

(C) $2\left(\sqrt{2}-1\right)$ (D) None

SECTION - B

Multiple Correct Answer Type

This section contains multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/are correct.

6. Select the correct statement(s)

(A) In an exothermic reaction, the total mass of reactant particles is greater than that of the product particles and the Q value of reaction is positive.

(B) An endothermic reaction does not occur unless the bombarding particle has a kinetic energy greater than |Q|

(C) Consider a bombarding particle X of mass m_1 and a target Y of mass m_2 (at rest). The threshold energy of X for endothermic reaction to take place is $K_{th} = |Q|\left(\frac{m_1}{m_2}+1\right)$

(D) Consider a bombarding particle X of mass m_1 and target Y of mass m_2 (at rest). The threshold energy of X for endothermic reaction to take place is $K_{th} = |Q|\left(\frac{m_2}{m_1}+1\right)$

7. Consider a radioactive sample having equal number of radio active nuclei A and B. A decays in X with decay constant λ. B decays in X and Y with decay constant λ and 2λ respectively. Initially number of nuclei are given as $N_A = N_B = N_0$ and $N_x = N_y = 0$. At any later instant t select the correct alternative(s) regarding number of nuclei of A, B, X and Y.

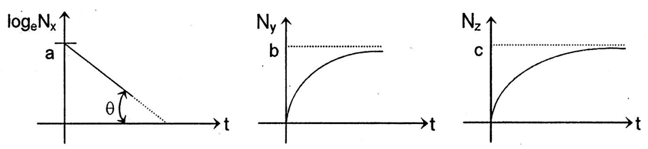
(A) $N_A = N_0 e^{-\lambda t}$

(B) $N_B = N_0 e^{-3\lambda t}$

(C) $N_x = N_0\left(\frac{4}{3}-\frac{1}{3}e^{-3\lambda t}\right)$

(D) $N_y = \frac{2N_0}{3}\left(1-e^{-3\lambda t}\right)$

8. An unstable radionuclei X can decay into two stable nuclei Y and Z. A sample containing only X is taken at t = 0, three graphs $\log_e(N_x)$ Vs t, N_y Vs t, N_z Vs t are drawn as shown below, here N_x, N_y and N_z represents number of nuclei of X, Y and Z respectively any instant t



Choose the correct choice(s) from the following

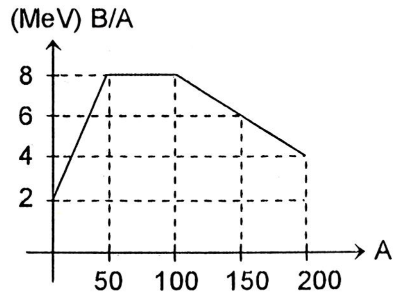
(A) Decay constant for decay of X into Y is $\frac{b\tan\theta}{e^a}$

(B) Decay constant for decay of X into Z is $\frac{c\tan\theta}{e^a}$

(C) Number of nuclei of X at t = 0 is e^a

(D) Half life of nuclei X is $\frac{1}{\tan\theta}$

9. If a graph of Binding energy (B/A) per nucleon versus mass number (A) looks like as shown in figure. Then using the curve choose correct option (s)



(A) Fusion of two nuclei with mass numbers 30 and 45 will have Q value 99 MeV

(B) Fission of nuclei with mass number 80 into two nuclei of equal mass number will have Q value 256 MeV

(C) Fission of nuclei with mass number 150 into two nuclei of equal mass number will release energy

(D) Fission of nuclei with mass number 80 into two nuclei of equal mass number will release energy

SECTION - C
Linked Comprehension Type

This section contains paragraph. Based upon this paragraph, some multiple choice questions have to be answered. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE OR MORE** is/are correct.

Paragraph for Question Nos. 10 to 12

The first nuclear reaction ever observed was by Ernest Rutherford. It was triggered by α-particles incident on an isotope of nitrogen $^{14}_{7}N$ nucleus. He observed a proton was emitted along with another element X. Let us assume that ${}^{14}_{7}N$ nucleus was initially stationary. For this reaction to occur, α-particle must touch the nitrogen nucleus. The distance between their centres at this moment is d. For this problem, we will neglect the effect of outer electrons in ${}^{14}_{7}N$. Symbols have their usual meanings

10. X is an isotope of
    (A) Nitrogen (B) Oxygen
    (C) Fluorine (D) Carbon

11. Value of d is
    (A) $R_0(2^{1/3} + 7^{1/3})$ (B) $R_0(2^{2/3} + 7^{2/3})$
    (C) $R_0(2^{2/3} + 14^{2/3})$ (D) $R_0(2^{2/3} + 14^{1/3})$

12. The minimum initial kinetic energy of α-particle so that reaction can occur is
    (A) $\dfrac{18ke^2}{R_0\left(2^{2/3}+14^{2/3}\right)}$ (B) $\dfrac{14ke^2}{R_0\left(2^{2/3}+14^{1/3}\right)}$
    (C) $\dfrac{18ke^2}{R_0\left(2^{2/3}+14^{1/3}\right)}$ (D) $\dfrac{14ke^2}{R_0\left(2^{2/3}+7^{2/3}\right)}$

Paragraph for Question Nos. 13 to 15

${}^{64}_{29}Cu$ can decay by β^- or β^+ emission, or electron capture. It is known that ${}^{64}_{29}Cu$ has a half life of 12.8 hrs with 40% probability of β^- decay, 20% probability of β^+ decay and 40% probability of electron capture. The mass of ${}^{64}_{29}Cu$ is 63.92977 amu while ${}^{64}_{30}Zn$ is 63.92914 amu and ${}^{64}_{28}Ni$ is 63.92796 amu (1amu = 931 MeV/C^2)

13. What is the half life for electron capture?
    (A) 5.12 Hrs (B) 32 Hrs
    (C) 2.56 Hrs (D) 16 Hrs

14. What is the Q value of β^- decay?
    (A) 0.587 MeV (B) 0.077 MeV
    (C) 1.686 MeV (D) 0.666 MeV

15. If initially there was 10^{22} atoms of ${}^{64}_{29}Cu$, what is the initial rate at which energy is being produced due to β^+ decay?
    (A) 5.8×10^4 W (B) 8.11×10^3 W
    (C) 8.4×10^2 W (D) 1.6×10^4 W

Paragraph for Questions 16 and 17

The mass of a nucleus ${}^{A}_{Z}X$ is less that the sum of the masses of (A–Z) number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of masses m_1 and m_2 only if $(m_1 + m_2) < M$. Also two light nuclei of masses m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M′ only if $(m_3 + m_4) > M'$. The masses of some neutral atoms are given in the table below :

${}^{1}_{1}H$	1.007825u	${}^{2}_{1}H$	2.014102u	${}^{3}_{1}H$	3.016050u	${}^{4}_{2}He$	4.002603u
${}^{6}_{3}Li$	6.015123u	${}^{7}_{3}Li$	7.016004u	${}^{70}_{30}Zn$	69.925325u	${}^{82}_{34}Se$	81.916709u
${}^{152}_{64}Gd$	151.919803u	${}^{206}_{82}Pb$	205.974455u	${}^{209}_{83}Bi$	208.980388u	${}^{210}_{84}Po$	209.982876u

16. The incorrect statement is/are
    (A) The nucleus ${}^{6}_{3}Li$ can emit an alpha particle
    (B) The nucleus ${}^{210}_{84}P_0$ can not emit a proton
    (C) Deuteron and alpha particle can undergo complete fusion
    (D) The nuclei ${}^{70}_{30}Zn$ and ${}^{82}_{34}Se$ can not undergo complete fusion

17. The kinetic energy (in MeV) of the alpha particle, when the nucleus ${}^{210}_{84}Po$ at rest undergoes alpha decay, is (approximately)
    (A) 4.8 (B) 5.4
    (C) 6.7 (D) 7.8

Paragraph for Question Nos. 18 to 20

The radionuclide ${}^{56}Mn$ is being produced in a cyclotron at a constant rate P by bombarding a maganese target with deuterons. ${}^{56}Mn$ has a half life of 2.5 hours and the target contains large number of only the stable maganese isotope ${}^{55}Mn$. The reaction that produces ${}^{56}Mn$ is

$$^{55}Mn + d \rightarrow {}^{56}Mn + p$$

After being bombarded for a long time, the activity of the target due to ${}^{56}Mn$ becomes constant equal to $13.86 \times 10^{10}\ s^{-1}$

(Use ln2 = 0.693 ; Avogadro No = 6×10^{23}, atomic weight ${}^{56}Mn$ = 56gm/mole)

18. At what constant rate P, ${}^{56}Mn$ nuclei will be produced in the cyclotron after a long time (>> 2.5 hours) ?
    (A) 2×10^{11} nuclei/s (B) 13.86×10^{10} nuclei/s
    (C) 9.6×10^{10} nuclei/s (D) 6.93×10^{10} nuclei/s

19. After a long time, number of ${}^{56}Mn$ nuclei present in the target, is equal to
    (A) 5×10^{11} (B) 20×10^{11}
    (C) 1.2×10^{14} (D) 1.8×10^{15}

20. After a long time bombardment, number of ^{56}Mn nuclei present in the target depends upon

(a) the number of ^{56}Mn nuclei present at the start of the process

(b) half life of the ^{56}Mn

(c) the constant rate of production P

(A) All (a), (b) and (c) are correct
(B) only (a) and (b) are correct
(C) only (b) and (c) are correct
(D) only (a) and (c) are correct

Paragraph for Question Nos. 21 to 23

Read the paragraph carefully and answer the following questions :

A nucleus kept at rest in the free space, break up into two smaller nuclei of masses m and 2m. Total energy generated in this fission is E. The bigger part is radioactive, emits five gamma ray photons in the direction of its velocity and finally comes to rest

(given $h = 6.6\times10^{-34}$ J-s, $m = 1.00\times10^{-26}$ kg, $E = 3.63\times10^{-8}\,mc^2$, $c = 3\times10^8$ m/s

21. Fractional loss of mass in the fission is

(A) 1.21×10^{-8} (B) 2.56×10^{-8}
(C) 1.73×10^{-8} (D) 3.52×10^{-8}

22. Velocity of smaller daughter nucleus is

(A) 5.6×10^4 m/s (B) 6.6×10^4 m/s
(C) 7.6×10^4 m/s (D) 8.6×10^4 m/s

23. The wavelength of the gamma ray is

(A) 0.02 Å (B) 0.03 Å
(C) 0.04 Å (D) 0.05 Å

SECTION-E

Integer Answer Type

This section contains Integer type questions. The answer to each of the questions is an integer.

24. A uranium reactor develops thermal energy at a rate of 320 MW. $\frac{x}{10}$ mg is the amount of ^{235}U being consumed every second. Average energy released per fission is 200 MeV. Calculate the integer closest to x.

25. 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 20A. Find the value of A. (Assume that daugther nucleus is in ground state

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ANSWERS

LEVEL-1

1. (A)	2. (C)	3. (A)	4. (B)	5. (A)	6. (A)
7. (D)	8. (A,B)	9. (D)	10. (D)		

LEVEL-2

1. (C)	2. (C)	3. (C)	4. (D)	5. (B)	6. (A,B,C)
7. (A,B,D)	8. (A,B,C)	9. (A,C)	10. (B)	11. (D)	12. (C)
13. (B)	14. (A)	15. (B)	16. (A)	17. (B)	18. (B)
19. (D)	20. (C)	21. (A)	22. (B)	23. (D)	24. (39)
25. (5)					