Nuclear Physics JEE Main PYQ - 1

Total Time: 20 Minute **Total Marks:** 40

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Nuclear Physics

1. Given the masses of various atomic particles $m_p = 1.0072u$, $m_n = 1.0087\,u$ $m_e = 0.000548u$, $m_{\overline{v}} = 0$, $m_d = 2.0141u$ where $p \equiv$ proton, $n \equiv$ neutron, $e \equiv$ electron, $\overline{v} \equiv$ antineutrino and $d \equiv$ deuteron. Which of the following process is allowed by momentum and energy conservation ? **(+4)**

[Sep.•06,2020•(II)]

a. $n + p \rightarrow d + \gamma$

b. $e^+ + e^- \rightarrow \gamma$

c. $n + n \rightarrow$ deuterium atom (electron bound to the nucleus)

d. $p \rightarrow n + e^+ + \overline{v}$

---

2. Find the binding energy per nucleon for $^{120}_{50}Sn$. Mass of proton $m_p = 1.00783\,U$, mass of neutron $m_n = 1.00867\,U$ and mass of tin nucleus $m_{Sn} = 119.902199\,U$ (take $1U = 931\,MeV$) **(+4)**

[Sep. 04,2020 (II)]

a. $8.5\,MeV$

b. $7.5\,MeV$

c. $8.0\,MeV$

d. $9.0\,MeV$

---

3. Condiser the nuclear fission $Ne^{20} -> 2He^4 + C^{12}$ Given that the binding energy/nucleon of Ne^{20}, He^4 and C^{12} are, respectively, 8.03 MeV, 7.07 MeV and 7.86 MeV, identify the correct statement : **(+4)**

[Sep. 02, 2020 (I)]

a. 8.3 MeV energy will be released

b. energy of 12.4 MeV will be supplied

c. energy of 11.9 MeV has to be supplied

d. energy of 3.6 MeV will be released

---

4. A radioactive nucleus decays by two different processes. The half life for the first process is $10s$ and that for the second is $100s$. the effective half life of the nucleus is close to: **(+4)**

[30-Jan-2023 Shift 2]

a. 9 sec

b. 55 sec

c. 6 sec

d. 12 sec

---

5. The activity of a radioactive sample falls from $700\,s^{-1}$ to $500\,s^{-1}$ in 30 minutes. Its half life is close to : **(+4)**

[29-Jun-2022-Shift-1]

a. 72 min

b. 62 min

c. 66 min

d. 52 min

---

6. Two radioactive materials A and B have decay constants 10λ and λ, respectively. It initially they have the same number of nuclei, then the ratio of the number of nuclei of A to that of B will be $1/e$ after a time : **(+4)**

[29-Jul-2022-Shift-2]

a. $\frac{11}{10\lambda}$

b. $\frac{1}{9\lambda}$

c. $\frac{1}{10\lambda}$

d. $\frac{1}{11\lambda}$

---

7. The ratio of mass densities of nuclei of $^{40}C_a$ and ^{16}O is close to :- **(+4)**

[30-Jan-2024•Shift•1]

a. 1

b. 2

c. 0.1

d. 5

---

8. A radioactive nucleus A with a half-life T, decays into a nucleus B. At $t = 0$, there is no nucleus B. At sometime t, the ratio of the number of B to that of A is 0.3. Then, t is given by : **(+4)**

[30-Jan-2023 Shift 2]

a. $t = \frac{T}{2}\frac{\log\ 2}{\log\ (1.3)}$

b. $t = T\frac{\log\ (1.3)}{\log\ 2}$

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

d. $t = \frac{T}{\log\ (1.3)}$

---

9. Nucleus A having $Z = 17$ and equal number of protons and neutrons has $12MeV$ binding energy per nucleonAnother nucleus B of $Z = 12$ has total 26 nucleons and $18MeV$ binding energy per nucleons The difference of binding energy of B and A will be $\_\_\_MeV$ **(+4)**

[1-Feb-2023 Shift 2]

---

10. A radioactive nucleus decays by two different process The half life of the first process is 5 minutes and that of the second process is $30s$. The effective half-life of the nucleus is calculated to be $\frac{\alpha}{11}$ s The value of α is $\_\_\_\_\_$ **(+4)**

[30-Jan-2023 Shift 2]

Answers

1. **Answer: a**

Explanation:

Only in case-I, $M_{LHS} > M_{RHS}$ i.e.
total mass on reactant side is greater then that on the product side. Hence it will only be allowed

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

2. **Answer: a**

Explanation:

B.E. $= [\Delta m] \cdot c^2$

$M_{\text{expected}} = ZM_p + (A - Z)M_n$

$= 50[1.00783] + 70[1.00867]$

$M_{\text{actual}} = 119.902199$

$B.E. = [50[1.00783] + 70[1.00867] - 119.902199] \times 931$

$= 1020.56$

$\frac{BE}{\text{nucleon}} = \frac{1020.56}{120}$

$= 8.5\, MeV$

The Correct Option is (A): $8.5\ MeV$

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

3. Answer: c

Explanation:

$Ne^{20} -> 2He^4 + C^{12}$

$8.30 \times 20 \quad 2 \times 7.07 \times 4 + 7.86 \times 12$

$\therefore\ E_B = (BE)_{react} - (BE)_{product} = 9.72\,MeV$

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

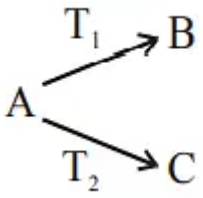
Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

4. Answer: a

Explanation:



$\frac{1}{T_{eff}} = \frac{1}{T_1} + \frac{1}{T_2}$
$T_{eff} = \frac{T_1 T_2}{T_1 + T_2}$
$= \frac{1000}{110} = \frac{100}{11} = 9.09$
$T_{eff} \cong 9$

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

5. Answer: b

Explanation:

$A = A_0 \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$
$500 = 700 \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$
$0.7 \approx \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$
$\left(\frac{1}{2}\right)^{1/2} \approx \frac{t}{T_{1/2}}$
$\frac{30}{T_{1/2}} \approx \frac{1}{2} \Rightarrow T_{1/2} = 60$

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

6. Answer: b

Explanation:

$N_1 = N_0 e^{-10\lambda t}$
$N_2 = N_0 e^{-\lambda t}$
$\frac{1}{e} = \frac{N_1}{N_2} = e^{-9\lambda t}$
$\Rightarrow 9\lambda t = 1$
$t = \frac{1}{9\lambda}$

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

7. **Answer: a**

Explanation:

The correct option is(A): 1

mass densities of all nuclei are same so their ratio is 1.

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

8. **Answer: b**

Explanation:

$\frac{N_0 - N_0 e^{-\lambda t}}{N_0 e^{-\lambda t}} = 0.3$
$\Rightarrow e^{\lambda t} = 1.3$
$\therefore \lambda t = \text{In } 1.3$
$\left(\frac{In\,2}{T}\right) t = \text{In } 1.3$

$t = T.\frac{In\,(1.3)}{In\,2}$
$t = T\frac{\log(1.3)}{\log 2}$

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

9. Answer: 6 - 6

Explanation:

The correct answer is 6.
For A mass number $= 34$
Total binding energy $= 1.2 \times 34 = 40.8\,MeV$
For B mass number $= 26$
total binding energy $= 1.8 \times 26\,MeV$
$= 46.8\,MeV$
Difference of $BE = 6\,MeV$

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit

---

10. **Answer: 300 - 300**

Explanation:

The correct answer is 300.

$\frac{dN_1}{dt} = -\lambda_1 N$

$\frac{dN_2}{dt} = -\lambda_2 N$

$\frac{dN}{dt} = -(\lambda_1 + \lambda_2) N$

$\Rightarrow \lambda_{eq} = \lambda_1 + \lambda_2$

$\Rightarrow \frac{1}{t_{1/2}} = \frac{1}{300} + \frac{1}{30} = \frac{11}{300}$

$\Rightarrow t_{1/2} = \frac{300}{11}$

Concepts:

1. Nuclei:

In the year 1911, Rutherford discovered the atomic nucleus along with his associates. It is already known that every atom is manufactured of positive charge and mass in the form of a nucleus that is concentrated at the center of the atom. More than 99.9% of the mass of an atom is located in the nucleus. Additionally, the size of the atom is of the order of 10-10 m and that of the nucleus is of the order of 10-15 m.

Read More: Nuclei

Following are the terms related to nucleus:

1. Atomic Number
2. Mass Number
3. Nuclear Size
4. Nuclear Density
5. Atomic Mass Unit