

Nuclei JEE Main PYQ – 3

Total Time: 50 Minute

Total Marks: 80

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.

Nuclei

1. In space communication, the sound waves can be sent from one place to another: (+4, -1)
- (A) Through space
 - (B) Through wires
 - (C) By superimposing it on undamped electro-magnetic
 - (D) None of these
-
2. A boy weighing 50 kg eats bananas. The energy content of banana is 1000cal, if this energy is used to lift the boy from the ground then the height through which he is lifted. (+4, -1)
-
3. Consider the earth as a uniform sphere of mass M and radius R . Imagine a straight smooth tunnel made through the earth which connects any two-point on its surface. Show that the motion of a particle of mass m along this tunnel under the action of gravitation would be simple harmonic. Hence, determine the time that a particle would take to go from one end to the other through the tunnel. (+4, -1)
- (A) $2 \sqrt{\frac{R^3}{GM}}$
 - (B) $\sqrt{\frac{R^3}{GM}}$
 - (C) $\frac{1}{2} \sqrt{\frac{R^3}{GM}}$
 - (D) None of these
-
4. Uranium has two isotopes of masses 235 and 238 units. If both of them are present in Uranium hexafluoride gas, what is the difference in speeds utilised in the enrichment of uranium needed for nuclear fission? If the atomic mass of fluorine is 19 units, estimate the percentage difference in speeds at any temperature. (+4, -1)
-

5. Find the energy equivalent of one atomic mass unit, first in Joules and then in (+4, -1)

- a. (A) 931.5
- b. (B) 932.5
- c. (C) 902.5
- d. (D) None of these

6. 4 g of a radioactive material having a half-life period of 2 years is kept in store (+4, -1)
for a duration of 4 years. The material remains unchanged (in grams or g) is
-----.

7. In a radioactive material, fraction of active material remaining after time t is (+4, -1)
 $9/16$. The fraction that was remaining after $t/2$ is :

- a. $\frac{3}{4}$
- b. $\frac{7}{8}$
- c. $\frac{4}{5}$
- d. $\frac{3}{5}$

8. In a radioactive decay chain, the initial nucleus is ${}_{90}^{232}\text{Th}$. At the end there are (+4, -1)
 6α -particles and 4β -particles which are emitted. If the end nucleus, ${}_{Z}^AX$, A
and Z are given by :

- a. $A = 208; Z = 80$
- b. $A = 202; Z = 80$
- c. $A = 200; Z = 81$
- d. $A = 208; Z = 82$

9. Half-lives of two radioactive elements A and B are 20 minutes and 40 minutes, respectively. Initially, the samples have equal number of nuclei. After 80 minutes, the ratio of decayed numbers of A and B nuclei will be : (+4, -1)

- a. 1 : 16
- b. 4 : 1
- c. 1 : 4
- d. 5 : 4

10. An unstable heavy nucleus at rest breaks into two nuclei which move away with velocities in the ratio of 8 : 27. The ratio of the radii of the nuclei (assumed to be spherical) is : (+4, -1)

- a. 8:27
- b. 4:09
- c. 3:02
- d. 2:03

11. A solution containing active cobalt ${}_{27}^{60}\text{Co}$ having activity of $0.8 \mu\text{Ci}$ and decay constant λ is injected in an animal's body. If 1 cm^3 of blood is drawn from the animal's body after 10 hrs of injection, the activity found was 300 decays per minute. What is the volume of blood that is flowing in the body ? ($1 \text{ Ci} = 3.7 \times 10^{10}$ decays per second and at $t = 10 \text{ hrs } e^{-\lambda t} = 0.84$) (+4, -1)

- a. 6 liters
- b. 7 liters
- c. 4 liters
- d. 5 liters

12. A sample of radioactive material A , that has an activity of 10 mCi ($1 \text{ Ci} = 3.7 \times 10^{10} \text{ decays/s}$), has twice the number of nuclei as another sample of a different radioactive material B which has an activity of 20 mCi . The correct choices for half-lives of A and B would then be respectively : (+4, -1)

- a. 20 days and 5 days
- b. 20 days and 10 days
- c. 5 days and 10 days
- d. 10 days and 40 days

13. 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, -1)

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

14. The ratio of mass densities of nuclei of $^{40}\text{C}_a$ and ^{16}O is close to :- (+4, -1)

- a. 1
- b. 2
- c. 0.1
- d. 5

15. 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, -1)

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

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

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

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

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

a. 72 min

b. 62 min

c. 66 min

d. 52 min

17. A radioactive nucleus decays by two different processes. The half life for the (+4, -1)
first process is 10 s and that for the second is 100 s . the effective half life of the
nucleus is close to:

a. 9 sec

b. 55 sec

c. 6 sec

d. 12 sec

18. Consider the nuclear fission $\text{Ne}^{20} \rightarrow 2\text{He}^4 + \text{C}^{12}$ Given that the binding (+4, -1)
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 :

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

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

- a. 8.5 MeV
- b. 7.5 MeV
- c. 8.0 MeV
- d. 9.0 MeV

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

- a. $n + p \rightarrow d + \gamma$
- b. $e^+ + e^- \rightarrow \gamma$
- c. $n + n \rightarrow$ deuterium atom (electron bound to the nucleus)
- d. $p \rightarrow n + e^+ + \bar{\nu}$

Answers

1. Answer: c

Explanation:

Explanation:

The electromagnetic waves do not need a medium to travel. So in space communication, the sound waves can be sent from one place to another by superimposing them on undamped electromagnetic waves. Hence, the correct option is (C).

2. Answer: 8.57 – 8.57

Explanation:

Explanation:

It is given that a boy weighing 50 kg eats bananas. So, mass of the boy, $m = 50$ kg. The energy content of the banana is given as 1000 cal. We know that one calorie is 4.2 J. Thus the given energy content in joules is: $E = 1000 \times 4.2 = 4200$ J. We need to find the height to which the man can be lifted using this energy. Let us suppose that the height through which he is lifted is h . We know that the energy at a height is the gravitational potential energy given as $E = mgh$. Where, m is the mass, g is acceleration due to gravity and h is the height. Let us equate the energy content of bananas to the value of this potential energy. $E = mgh$. From this, we can find the value of h as $h = \frac{E}{mg}$. We know that the value of g is 9.8 m/s^2 . Let us substitute all the given values in this equation. $h = \frac{4200}{50 \times 9.8} = 8.57 \text{ m}$. This is the height to which the boy can be lifted using the given energy content of the banana. Hence, the correct answer is 8.57 m.

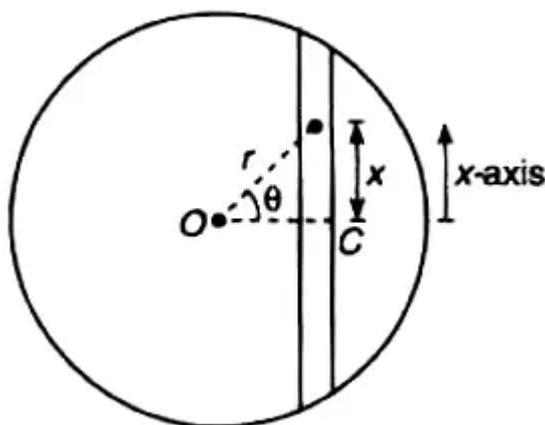
3. Answer: b

Explanation:

Explanation:

Suppose at some instant the particle is at radial distance r from centre of earth.

Since, the particle is constrained to move along the tunnel, we define its position as distance x from C . Thus, the equation of motion of the particle is,



The gravitational force on mass m at distance x is, $F = -\frac{GMmx}{R^3}$ (towards C)
 Therefore, $F = -m \sin \theta = -\frac{GMm}{R^3}(-x) = -\frac{GMm}{R^3}x$ Since, $\frac{GM}{R^3} = \frac{g}{R}$, motion is simple harmonic in nature. Further, $\omega = \frac{g}{R}$ or $T = 2\pi \sqrt{\frac{R}{g}}$ Time period of oscillation is,
 $T = 2\pi \sqrt{\frac{R}{g}} = 2\pi \sqrt{\frac{R}{g}}$ The time taken by particle to go from one end to the other is $\frac{T}{2}$
 $= \pi \sqrt{\frac{R}{g}}$ Hence, the correct option is (B).

4. Answer: 0.64 - 0.64

Explanation:

Explanation:

At a fixed temperature average $\frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_2 v_2^2$ or $\frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}}$ Given

$M_1 = 235 \text{amu}$ and $M_2 = 238 \text{amu}$ $\frac{v_1}{v_2} = \sqrt{\frac{238}{235}} = 1.0064$ or $v_1 = 1.0064 v_2$

Percentage ratio $= \frac{v_1 - v_2}{v_2} \times 100 = \frac{1.0064 - 1}{1} \times 100 = 0.64$ Hence, the correct answers are 0.64.

5. Answer: a

Explanation:

Explanation:

We know that 1 Atomic Mass Unit (amu) = $1.66 \times 10^{-27} \text{ kg}$ And Speed of Light,

$= 3 \times 10^8 \text{ ms}^{-1}$ $E = mc^2$ or $E = 1.66 \times 10^{-27} \times (3 \times 10^8)^2 = 1.494 \times 10^{-10} \text{ joule}$ Now we have to

convert this into MeV. $1\text{MeV} = 1.6 \times 10^{-13}$ Joules. The energy of one atomic mass unit converted into MeV will be $\frac{1.494 \times 10^{-10}}{1.6 \times 10^{-13}} = 933.75\text{MeV}$. Hence, the correct option is (A).

6. Answer: 1 - 1

Explanation:

Explanation:

Given: The initial amount of the sample, $M_0 = 4$ g Half life, $t_{1/2} = 2$ years We have to find how much of the material remains unchanged after 4 years. Number of half lives in a duration of 4 years is $= \frac{4}{2} = 2$ According to the law of radioactive decay, $= 4\left(\frac{1}{2}\right)^2 = 1$ This is the amount of radioactive material that remains unchanged after 4 years. Hence, the correct answer is 1.00.

7. Answer: a

Explanation:

First order decay

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

$$\text{Given } N(t)/N_0 = 9/16 = e^{-\lambda t}$$

$$\text{Now, } N(t/2) = N_0 e^{-\lambda t/2}$$

$$\frac{N(t/2)}{N_0} = \sqrt{e^{-\lambda t}}$$

$$= \sqrt{9/16}$$

$$N(t/2) = 3/4 N_0$$

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
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5. Atomic Mass Unit

8. Answer: d

Explanation:

The correct answer is (D) : $A = 208$; $Z = 82$

When one α -particle is emitted, then the mass number (A) of daughter nuclei decreases by 4 and the atomic number decreases by 2.



When one β -particle is emitted, then the mass number (A) of daughter nuclei increases by 1 and the atomic number remains the same.



Therefore, for the end nucleus, $A = 208$: $Z = 82$

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9. Answer: d

Explanation:

80 minutes = 4 half-lives of A = 2 half-lives of B

Let the initial number of nuclei in each sample be N

$$N_A \text{ after 80 minutes} = \frac{N}{2^4}$$

$$\Rightarrow \text{Number of } A \text{ nuclides decayed} = \frac{15}{16}N$$

$$N_B \text{ after 80 minutes} = \frac{N}{2^2}$$

$$\Rightarrow \text{Number of } B \text{ nuclides decayed} = \frac{3}{4}N$$

$$\text{Required ratio} = \frac{15/16}{3/4} = \frac{5}{4}$$

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10. Answer: c

Explanation:

The two nuclei have velocity in ratio 8 : 27. By conservation of momentum, we have

$$m_1 v_1 = m_2 v_2$$

$$\Rightarrow \frac{v_1}{v_2} = \frac{m_2}{m_1}$$

$$\Rightarrow \frac{m_2}{m_1} = \frac{8}{27}$$

Now, since $m = \rho \frac{4}{3} \pi r^3$

$$\text{Therefore } \frac{m_2}{m_1} = \frac{\rho \frac{4}{3} \pi r_2^3}{\rho \frac{4}{3} \pi r_1^3}$$

$$\Rightarrow \frac{m_2}{m_1} = \left(\frac{r_2}{r_1} \right)^3$$

$$\Rightarrow \left(\frac{r_2}{r_1} \right)^3 = \frac{8}{27}$$

$$\Rightarrow \frac{r_2}{r_1} = \frac{2}{3}$$

Thus, ratio of radii of nuclei $r_1 : r_2 = 3 : 2$.

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11. Answer: d

Explanation:

We know that

$$\frac{dN}{dt} = -N_0\lambda e^{-\lambda t}$$

It is given that activity = $0.8\mu Ci$. Therefore, $\lambda N_0 = 0.8\mu Ci$.

Given: If 1 cm^3 of blood is drawn from the animal's body after 10 hours of injection then activity was 300 decays per minute.

Let V be the volume of blood flowing, then activity reduces as $\frac{1}{V}$. Thus,

$$\frac{1}{V} \times \lambda N_0 e^{-\lambda t} = \frac{300}{60}$$

Put $\lambda N_0 = 0.8\mu Ci$, $e^{-\lambda t} = 0.84$, $Ci = 3.7 \times 10^{10}$ in above equation, we obtain

$$\frac{1}{V} \times 0.8 \times 10^{-6} \times 3.7 \times 10^{10} \times 0.84 = \frac{300}{60}$$

$$\Rightarrow \frac{1}{V} \times 24.86 = 5$$

$$\Rightarrow V = \frac{24.86}{5} = 4.97 \sim 5$$

Therefore, volume of blood flowing = 5 litres

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12. Answer: a

Explanation:

$$\text{Activity } A = \lambda N$$

$$\text{For A } 10 = (2N_0) \lambda_A$$

$$\text{For B } 20 = N_0 \lambda_B$$

$$\therefore \lambda_B = 4\lambda_A \Rightarrow (T_{1/2})_A = 4(T_{1/2})_B$$

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13. Answer: b

Explanation:

$$\frac{N_0 - N_0 e^{-\lambda t}}{N_0 e^{-\lambda t}} = 0.3$$

$$\Rightarrow e^{\lambda t} = 1.3$$

$$\therefore \lambda t = \ln 1.3$$

$$\left(\frac{\ln 2}{T}\right) t = \ln 1.3$$

$$t = T \cdot \frac{\ln(1.3)}{\ln 2}$$

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

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Read More: [Nuclei](#)

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14. Answer: a

Explanation:

The correct option is(A): 1

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

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15. Answer: b

Explanation:

$$N_1 = N_0 e^{-10\lambda t}$$

$$N_2 = N_0 e^{-\lambda t}$$

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

$$\Rightarrow 9\lambda t = 1$$

$$t = \frac{1}{9\lambda}$$

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16. Answer: b

Explanation:

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

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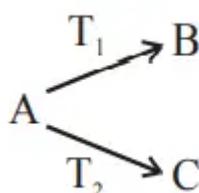
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17. Answer: a

Explanation:



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

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18. Answer: c

Explanation:

$$\begin{aligned}Ne^{20} &\rightarrow 2He^4 + C^{12} \\ 8.30 \times 20 &= 2 \times 7.07 \times 4 + 7.86 \times 12 \\ \therefore E_B &= (BE)_{react} - (BE)_{product} = 9.72 \text{ MeV}\end{aligned}$$

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Read More: [Nuclei](#)

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19. Answer: a

Explanation:

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

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

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

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

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

$$= 1020.56$$

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

$$= 8.5 \text{ MeV}$$

The Correct Option is (A): 8.5 MeV

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20. **Answer: a**

Explanation:

Only in case-I, $M_{LHS} > M_{RHS}$ i.e.

total mass on reactant side is greater than that on the product side. Hence it will only be allowed

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