Nuclei JEE Main PYQ - 2

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.

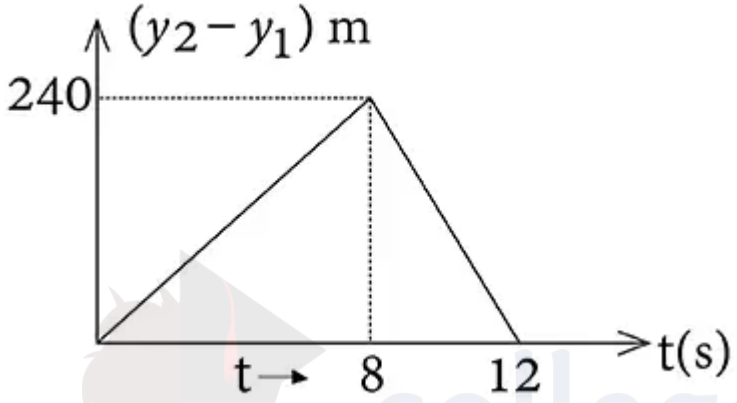
Navigating & Answering a Question

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.

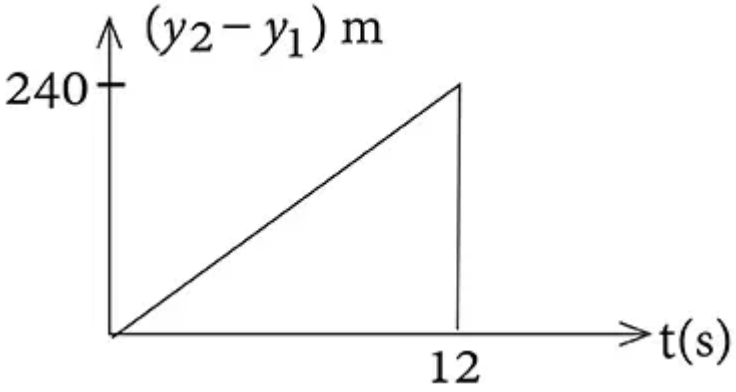
Nuclei

1. Two stones are thrown up simultaneously from the edge of a cliff 240 high with initial speed 10 and 40 respectively. Which of the following graph best represents the time variation of the relative position of the second stone with respect to the first?(Assume stones do not rebound after hitting the ground and neglect air resistance, take = 10 / ^{2}) **(+4, -1)**

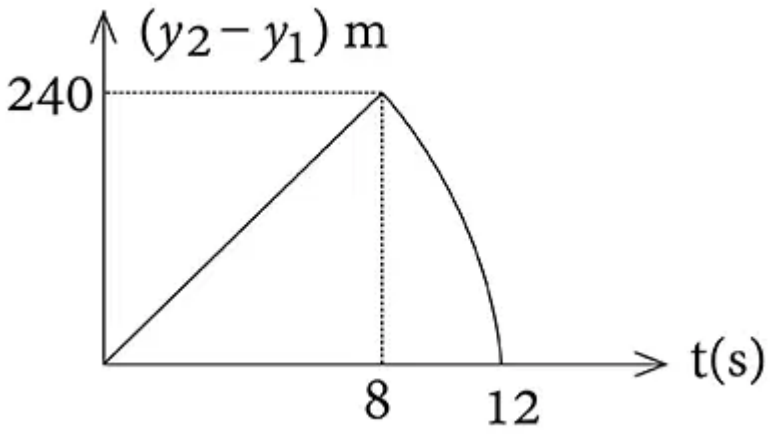
a. (A)



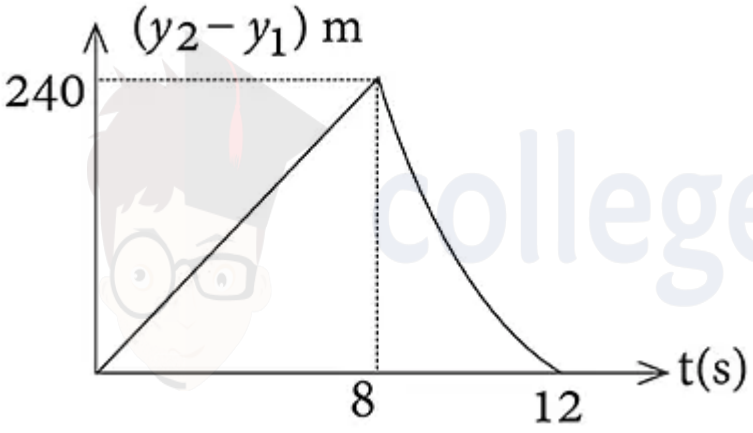
b. (B)



c. (C)



d. (D)



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2. A train is moving on a straight track with speed 20 ms^{-1}. It is blowing its whistle at the frequency of 1000 Hz. What is the percentage change in frequency heard by a person standing near the track as the train passes by it? (speed of sound =320 ms^{-1}) **(+4, -1)**

a. (A) 6%

b. (B) 12%

c. (C) 18%

d. (D) 24%

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3. In a line of sight radio communication, a distance of about 50 km is kept between the transmitting and receiving antennas. If the height of the receiving antenna is 70 m, then the minimum height of the transmitting antenna should be :
(Radius of the Earth $= 6.4 \times 10^6$ m) **(+4, -1)**

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4. Two identical photocathodes receive light of frequencies $_1$ and $_2$. If the velocities of the photoelectrons (of mass) coming out are $_1$ and $_2$, respectively, then: **(+4, -1)**

a. (A) $_1 - _2 = [\frac{2}{}(_1 - _2)]^{\frac{1}{2}}$

b. (B) $\frac{2}{1} - \frac{2}{2} = \frac{2}{}(_1 - _2)$

c. (C) $_1 + _2 = [\frac{2}{}(_1 - _2)]^{\frac{1}{2}}$

d. (D) $\frac{2}{1} + \frac{2}{2} = \frac{2}{}(_1 - _2)$

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5. The ratio of magnetic field and magnetic moment at the centre of a current carrying circular loop is X. When both the current and radius is doubled the ratio will be **(+4, -1)**

a. (A) $\frac{}{8}$

b. (B) $\frac{}{4}$

c. (C) $\frac{}{2}$

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

---

6. The equation of motion of system is given by $\ddot{} + \dot{} + = 0$. The damped vibration, can be written as: **(+4, -1)**

a. (A) $= (\sqrt{1 - ^2})$

b. (B) $= \sqrt{(\ )^2 - (\frac{}{2})^2}$

c. (C) Both A and B

d. (D) Neither A nor B

7. If half life of a radio-active nuclide A is equal to average life of another radio-active nuclide B. Find the ratio of decay constant of A to that of B. **(+4, -1)**

   a. In 2:1

   b. 1: In 2

   c. 2: In 2

   d. In 2:2

8. For the given radioactive decay ${}^{298}_{94}X \rightarrow {}^{294}_{92}X + {}^{4}_{2}\alpha + Q$ - value, binding energy per nucleon of X, Y and a are a, b and c. The Q - value is equal to **(+4, -1)**

   a. 294b + 4c - 298a

   b. 92b + 2c - 94a

   c. 92b + 2c - 94a

   d. 92b + 2c + 94a

9. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R **(+4, -1)**
   Assertion (A): The nuclear density of nuclides ${}^{10}_{5}B, {}^{6}_{3}Li, {}^{56}_{26}Fe, {}^{20}_{10}Ne$ and ${}^{209}_{83}Bi$ can be arranged as $\rho^N_{Bi} > \rho^N_{Fe} > \rho^N_{Ne} > \rho^N_B > \rho^N_{Li}$.
   Reason R: The radius R of nucleus is related to its mass number A as $R = R_0 A^{1/3}$, where R_0 is a constant.
   In the light of the above statements, choose the correct answer from the options given below

   a. Both A and R are true and R is the correct explanation of A

   b. A is false but R is true

   c. Both A and R are true but R is NOT the correct explanation of A

   d. A is true but R is false

10. The energy released per fission of the nucleus of $^{240}\mathrm{X}$ is $200\,\mathrm{MeV}$. The energy released if all the atoms in $120\,\mathrm{g}$ of pure $^{240}\mathrm{X}$ undergo fission is _____ $10^{25}\,\mathrm{MeV}$. (Given $N_A = 6 \times 10^{23}$) **(+4, -1)**

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11. Assume that protons and neutrons have equal masses Mass of a mucleon is $16 \times 10^{-27} kg$ and radius of nucleus is $15 \times 10^{-15} A^{1/3} m$ The approximate ratio of the nuclear density and water density is $n \times 10^{13}$ The value of n is ___ **(+4, -1)**

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12. A nucleus disintegrates into two smaller parts, which have their velocities in the ratio $3:2$ The ratio of their nuclear sizes will be $\left(\frac{x}{3}\right)^{\frac{1}{3}}$ The value of ' x ' is:- **(+4, -1)**

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13. 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, -1)**

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14. 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)**

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15. Consider the following radioactive decay process $^{218}_{84}A \xrightarrow{\alpha} A_1 \xrightarrow{\beta^-} A_2 \xrightarrow{\gamma} A_3 \xrightarrow{\alpha} A_4 \xrightarrow{\beta^+} A_5 \xrightarrow{\gamma} A_6$ The mass number and the atomic number of A_6 are given by: **(+4, -1)**

a. 211 and 80

b. 210 and 80

c. 210 and 82

d. 210 and 84

---

16. The ratio of the density of oxygen nucleus $\left(^{16}_{8}O\right)$ and helium nucleus $\left(^{4}_{2}He\right)$ is **(+4, -1)**

a. $4:1$

b. $1:1$

c. $8:1$

d. $2:1$

---

17. The mass of proton, neutron and helium nucleus are respectively $10073\,u$, $10087\,u$ and $40015\,u$ The binding energy of helium nucleus is: **(+4, -1)**

a. $14.2\,MeV$

b. $7.1\,MeV$

c. $56.8\,MeV$

d. $28.4\,MeV$

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18. A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected in the region such that its velocity is pointed along the direction of fields, then the electron: **(+4, -1)**

a. (A) will turn towards right of direction of motion

b. (B) speed will decrease

c. (C) speed will increase

d. (D) will tum towards left of direction of motion

---

19. A particle moves in straight line with acceleration described by $a=mx-v^2/x$. if the initial velocity and displacement are v and zero and at any time t velocity and displacement are 0 and x. the value of constant m is: **(+4, -1)**

a. (A) $3^2/2^2$

b. (B) $3^3/3^2$

c. (C) $5^2/2^2$

d. (D) None of these

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20. An aeroplane execute a horizontal loop at a speed of 720 with its wings banked at 45 . What is the radius of the loop? Take = 10 $^{-2}$ **(+4, -1)**

a. (A) 4

b. (B) 4.5

c. (C) 7.2

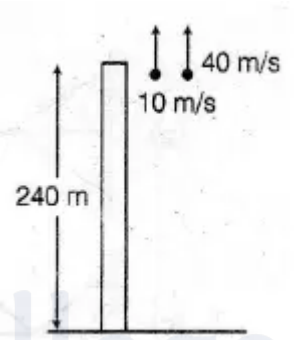
d. (D) 2

Answers

1. Answer: c

Explanation:

Explanation:
The concept of relative motion can be applied to predict the nature of the motion of one particle with respect to the other.Consider the stones thrown up simultaneously as shown in the diagram below.



Considering the motion of the second particle with respect to the first we have relative acceleration.$|\ _{21}\ | = |\ _{2} - \ _{1}\ | = \ - \ = 0$Thus, motion of first particle is straight line with respect to second particle till the first particle strikes ground at a time given by$-240 = 10\ \ - \frac{1}{2} \times 10 \times \ ^{2}$ or $\ ^{2} - 2\ \ - 48 = 0$or $\ ^{2} - 8\ \ + 6\ \ - 48 = 0$or $\ \ = 8 - 6$ (not possible)Thus, distance covered by second particle with respect to first particle in 8 is $\ _{12} = (\ _{21})\ \ = (40 - 10)(8\ \ ) = 30 \times 8 = 240$ Similarly, time taken by second particle to strike the ground is given by,$-240 = 40\ \ - \frac{1}{2} \times 10 \times \ ^{2}$ or $240 = 40\ \ - 5\ ^{2}$ or $5\ ^{2} - 40\ \ - 240 = 0$or $\ ^{2} - 8\ \ - 48 = 0\ ^{2} - 12\ \ + 4\ \ - 48 = 0$or $(\ \ - 12) + 4(\ \ - 12) = 0$or $\ \ = 12, - 4$ (not possible)Thus, after 8 s, the magnitude of relative velocity will increase up to 12 when the second particle strikes the ground.Hence, the correct option is (C).

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2. Answer: b

Explanation:

Explanation:
The frequency heard by the listener when train is moving towards the listener is given by, $\ ' = \frac{}{-}\ \ \ \ f' = \frac{1000v}{v - 20}$The frequency heard by the listener when train is moving away

from the listener is given by, $f'' = \frac{}{+}$ $f'' = \frac{1000v}{v+20}$And percentage change in frequency will be given by,Percentage change $= \frac{f' - f''}{f} \times 100 = \frac{\frac{1000v}{v-20} - \frac{1000v}{v+20}}{1000} \times 100$ $= \frac{40v}{(v+20)(v-20)} \times 100 = \frac{40 \times 320}{(320+20)(320-20)} \times 100$Percentage change $= \frac{40 \times 320}{340 \times 300} \times 100$ = 12.459% ≈ 12%Hence, the correct option is (B).

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3. Answer: 32 - 32

Explanation:

Explanation:
Given:
Distance between the transmitting and receiving antenna = 50 km
Height of the receiving antenna is = 70m
We have to find the hight of transmission antenna ,
Range $= \sqrt{2} + \sqrt{2}$
$50 \times 10^3 = \sqrt{2 \times 6400 \times 10^3 \times} + \sqrt{2 \times 6400 \times 10^3 \times 70}$
On solving = 32 Hence, the correct answer is 32.

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4. Answer: b

Explanation:

Explanation:
Let work function be , $_1$ and $_2$ be kinetic energies for $_1$ and $_2$ respectively, when frequency is $_1$ $_1 = {}_1 -$ ... (1)when frequency is $_2$ $_2 = {}_2 -$ ... (2)
(1) − (2) $_1 - {}_2 = {}_1 - {}_2$ but $= \frac{^2}{2} \frac{(^2_1 - ^2_2)}{2} = (_1 - {}_2)$ $^2_1 - {}^2_2 = \frac{2(_1 - {}_2)}{}$Hence, the correct option is (B).

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5. Answer: a

Explanation:

Explanation:
Given:The ratio of the magnetic field and magnetic moment at the center of a current-carrying circular loop = XWe have to find the ratio when both the current and radius is doubled.Magnetic field at the centre of current carrying loop is given by

$= \frac{0}{2}$....(i)where: =currentr=radiusLet M be the magnetic moment of the current carrying loop, so = = (^{2}).....(ii) [as = ^{2}]Dividing eq. (i) by eq. (ii), we get $- = \frac{0}{2}[\frac{1}{(\ ^2)}]$ $= - = \frac{0}{2^{\ 3}}$ $\frac{1}{3}$Thus, the ratio is independent of current and inversely proportional to the cube of radius. When the radius is doubled i.e. $'$ = 2 , then the new ratio is $\frac{1}{8^{\ 3}}$ $'$ = $\frac{}{8}$Hence, the correct option is (A).

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6. Answer: c

Explanation:

Explanation:
The general case of damped harmonic motion: = $\frac{^2}{_2}$ + — + = 0Where = the stiffness of spring, = damping coefficient and = massDamped vibration of a system is defined as: = $\sqrt{(\quad)^2 - (\frac{}{2})^2}$ (1)Damping ratio ( ) : It is defined as the ratio of actual damping to the critical damping. = $\frac{\text{actual damping}}{\text{critical damping}}$ = —
= — = $\frac{}{2}$ = $\frac{}{2\sqrt{\ \ 2}}$ = Substitute the value of in equation 1, we get,
= $\sqrt{(\quad)^2 - (\frac{}{2})^2}$ = $\sqrt{(\quad)^2 - (\quad)^2}$ = ($\sqrt{1 - ^2}$) Hence the correct option is (C).

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7. Answer: a

Explanation:

The correct option is (A): In 2:1

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: a**

Explanation:

The correct option is (A): 294b + 4c - 298a

Q-value = $(B.E)_{product}-(B.E)_{reaction}$

Concepts:

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9. **Answer: b**

Explanation:

Assertion A states that the nuclear densities follow the order: ρ Bi > ρ Fe > ρ Ne > ρ B > ρ Li.
Reason R states that the radius of a nucleus is related to its mass number A as R = $R_0 A^{\frac{1}{3}}$, where R_0 is a constant.
These two statements do not have a direct connection. The arrangement of nuclear densities does not directly relate to the formula for nuclear radius.
Nuclear density is independent of A.

So, the correct answer is (B): A is false but R is true.

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Read More: Nuclei

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---

10. Answer: 6 - 6

Explanation:

The number of moles of $^{240}\mathrm{X}$ in $120\,\mathrm{g}$ is:

$$\text{No. of moles} = \frac{\text{Mass}}{\text{Molar Mass}} = \frac{120}{240} = 0.5\,\text{moles}$$

The number of nuclei in 0.5 moles is:

$$\text{No. of nuclei} = 0.5 \cdot N_A = 0.5 \cdot 6 \times 10^{23} = 3 \times 10^{23}$$

The total energy released is:

$$E = (\text{No. of nuclei}) \cdot (\text{Energy per fission})$$

Substitute:

$$E = (3 \times 10^{23}) \cdot (200) = 6 \times 10^{25}\,\text{MeV}$$

Thus, the total energy released is $6 \times 10^{25}\,\text{MeV}$.

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---

11. Answer: 11 - 11

Explanation:

The density of a nucleus is:

$$\rho = \frac{\text{mass of nucleus}}{\text{volume of nucleus}}.$$

1. Mass of the nucleus: The mass of a single nucleon is:

$$m = 1.6 \times 10^{-27}\,\text{kg}.$$

2. Volume of the nucleus: The volume of a nucleus is given by:

$$V = \frac{4}{3}\pi R^3,$$

where $R = 1.5 \times 10^{-15}\,\text{m}$. Substituting:

$$V = \frac{4}{3}\pi (1.5 \times 10^{-15})^3 = \frac{4}{3}\pi \cdot 3.375 \times 10^{-45}.$$

Approximate:

$$V \approx 14.14 \times 10^{-45}\,\text{m}^3.$$

3. Nuclear density (ρ):

$$\rho = \frac{m}{V} = \frac{1.6 \times 10^{-27}}{14.14 \times 10^{-45}} \approx 0.113 \times 10^{18}\,\text{kg/m}^3.$$

4. Water density (ρ_w):

$$\rho_w = 10^3\,\text{kg/m}^3.$$

5. Ratio of nuclear density to water density:

$$\frac{\rho}{\rho_w} = \frac{0.113 \times 10^{18}}{10^3} = 0.113 \times 10^{15} = 11.31 \times 10^{13}.$$

Thus, the approximate ratio is:

$$n = 11.$$

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Read More: Nuclei

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---

12. Answer: 2 - 2

Explanation:

The correct answer is 2.

$$\frac{v_1}{v_2} = \frac{3}{2}$$

$m_1v_1 = m_2v_2 \Rightarrow \frac{m_1}{m_2} = \frac{2}{3}$

Since, Nuclear mass density is constant

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

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

$\frac{r_1}{r_2} = \left(\frac{2}{3}\right)^{\frac{1}{3}}$

So, $x = 2$

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---

13. Answer: 300 - 300

Explanation:

The correct answer is 300.

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

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

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

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

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

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---

14. Answer: 6 - 6

Explanation:

Step 1: Calculate the Mass Number of Nucleus A

Nucleus A has $Z = 17$ (number of protons). Since it has an equal number of protons and neutrons, the number of neutrons is also 17. The mass number (A) is the sum of protons and neutrons:

$$A = 17 + 17 = 34$$

Step 2: Calculate the Total Binding Energy of Nucleus A

The binding energy per nucleon for nucleus A is $1.2\,\mathrm{MeV}$. The total binding energy is the product of the binding energy per nucleon and the mass number:

$$BE_A = 1.2 \times 34 = 40.8\,\text{MeV}$$

Step 3: Calculate the Total Binding Energy of Nucleus B

Nucleus B has 26 nucleons, and the binding energy per nucleon is $1.8\,\text{MeV}$:

$$BE_B = 1.8 \times 26 = 46.8\,\text{MeV}$$

Step 4: Calculate the Difference in Binding Energies

The difference in binding energies is:

$$\Delta BE = BE_B - BE_A = 46.8 - 40.8 = 6\,\text{MeV}$$

Conclusion: The difference in binding energy is $6\,\text{MeV}$.

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---

15. Answer: b

Explanation:

1. During the first α-decay:

$$^{218}_{84}A \xrightarrow{\alpha} ^{214}_{82}A_1$$

The mass number decreases by 4, and the atomic number decreases by 2. 2. During the β^--decay:

$$^{214}_{82}A_1 \xrightarrow{\beta^-} ^{214}_{83}A_2$$

The mass number remains the same, and the atomic number increases by 1. 3. During the γ-decay:

$$^{214}_{83}A_2 \xrightarrow{\gamma} ^{214}_{83}A_3$$

There is no change in the mass number or the atomic number. 4. During the second α-decay:

$$^{214}_{83}A_3 \xrightarrow{\alpha} ^{210}_{81}A_4$$

The mass number decreases by 4, and the atomic number decreases by 2. 5. During the β^+-decay:

$$^{210}_{81}A_4 \xrightarrow{\beta^+} ^{210}_{80}A_5$$

The mass number remains the same, and the atomic number decreases by 1. 6. During the final γ-decay:

$$^{210}_{80}A_5 \xrightarrow{\gamma} ^{210}_{80}A_6$$

There is no change in the mass number or the atomic number.
Final Answer: The mass number and atomic number of A_6 are:

$$\boxed{210 \text{ and } 80}$$

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Read More: Nuclei

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---

16. Answer: b

Explanation:

1. Nuclear density is given by:

$$\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{A_u}{\frac{4}{3}\pi R^3}.$$

2. Substituting $R = R_0 A^{1/3}$, nuclear density becomes:

$$\rho = \frac{A_u}{\frac{4}{3}\pi (R_0 A^{1/3})^3} = \frac{A_u}{\frac{4}{3}\pi R_0^3 A}.$$

3. Simplifying:

$$\rho = \frac{3A_u}{4\pi R_0^3}.$$

4. Since nuclear density is independent of mass number A, the ratio is:

$$\rho_{\text{O}} : \rho_{\text{He}} = 1 : 1.$$

Thus, the ratio is **1:1**. Nuclear density is constant for all nuclei because the nuclear force binds nucleons in a fixed volume, irrespective of A.

Concepts:

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Read More: Nuclei

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---

17. Answer: d

Explanation:

B.E. of Helium $= (2m_P + 2m_N - m_{He})c^2 = 28.4MeV$

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

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18. Answer: b

Explanation:

Explanation:
Force on electron due to electric field, = − Force on electron due to magnetic field, = − (×) = 0Since vector and vector B are in the same direction.Total force on the electron. = + = − Electric field opposes the motion of the electron, hence speed of the electron will decrease.Hence, the correct option is (B).

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19. Answer: a

Explanation:

Explanation:
At, t = 0Initial velocity $_0$ = and displacement $_0$ = 0At, t = t . Final velocity = 0 and displacement = Now according to the law of kinematics. ^{2} = ^{2} + 2
$v^2 = v_0^2 + 2 \times a \times (s - s_0)$ $a = \frac{(^2 - ^2_0)}{2(\ -\ )} = \frac{0 - ^2}{2} =$ ^{2} / 2xgiven; = − ^{2}
− ^{2} / = ^{2} / 2 = 3 ^{2} / 2 = 3 ^{2} / 2 ^{2} Hence, the correct option is (A).

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20. Answer: a

Explanation:

Explanation:
Given that = 720 = $720 \times \frac{5}{18}$ / = 200 / = 45 = 10 / ^{2} Bank angle, tan = $\frac{^2}{}$ = $\frac{200^2}{10 \times \tan 45}$ = 4000 = 4 Hence, the correct option is (A).