Atoms and Nuclei

Question1

The radius of third stationary orbit of electron for Bohr's atom is R. The radius of fourth stationary orbit will be:
[27-Jan-2024 Shift 1]

Options:

A. $\frac{4}{3}$R

B. $\frac{16}{9}$R

C. $\frac{3}{4}$R

D. $\frac{9}{16}$R

Answer: B

Solution:

$$r \propto \frac{n^2}{Z}$$

$$\frac{r_4}{r_3} = \frac{4^2}{3^2}$$

$$r_4 = \frac{16}{9}R$$

Question2

If Rydberg's constant is R, the longest wavelength of radiation in Paschen series will be $\frac{\alpha}{7R}$, where α = ____
[27-Jan-2024 Shift 2]

Answer: 144

Solution:

Longest wavelength corresponds to transition between n = 3 and n = 4

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = RZ^2\left(\frac{1}{9} - \frac{1}{16}\right)$$

$$= \frac{7RZ^2}{9 \times 16}$$

$$\Rightarrow \lambda = \frac{144}{7R} \text{ for } Z = 1$$

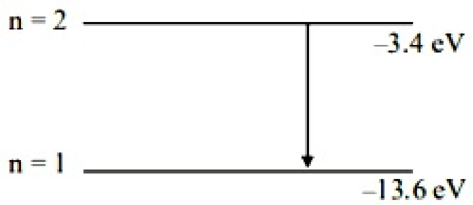
$$\therefore \alpha = 144$$

Question3

When a hydrogen atom going from n = 2 to n = 1 emits a photon, its recoil speed is $\frac{X}{5}$m / s. Where x = ____ (Use : mass of hydrogen atom $= 1.6 \times 10^{-27}$ kg)
[29-Jan-2024 Shift 1]

Answer: 17

Solution:



$\Delta E = 10.2$ eV

$$\text{Recoil speed (v)} = \frac{\Delta E}{mc}$$

$$= \frac{10.2 \text{ eV}}{1.6 \times 10^{-27} \times 3 \times 10^8}$$

$$= \frac{10.2 \times 1.6 \times 10^{-19}}{1.6 \times 10^{-27} \times 3 \times 10^8}$$

$$v = 3.4 \text{m}/s = \frac{17}{5} \text{m}/s$$

Therefore, x = 17

Question4

Given below are two statements:
Statement I: Fluorine has most negative electron gain enthalpy in its group.
Statement II: Oxygen has least negative electron gain enthalpy in its group.
In the light of the above statements, choose the most appropriate from

the options given below.
[29-Jan-2024 Shift 2]

Options:

A. Both Statement I and Statement II are true

B. Statement I is true but Statement II is false

C. Both Statement I and Statement II are false

D. Statement I is false but Statement II is true

Answer: D

Solution:

Solution:
Statement-1 is false because chlorine has most negative electron gain enthalpy in its group.

Question5

Hydrogen atom is bombarded with electrons accelerated through a potential different of V, which causes excitation of hydrogen atoms. If the experiment is being formed at T = 0K. The minimum potential difference needed to observe any Balmer series lines in the emission spectra will be $\frac{\alpha}{10}$V, where α = ___
[29-Jan-2024 Shift 2]

Answer: 121

Solution:

Solution:
For minimum potential difference electron has to make transition from n=3 to n=2 state but first electron has to reach to n = 3 state from ground state. So, energy of bombarding electron should be equal to energy difference of n=3 and n=1 state.

$$\Delta E = 13.6\left[1 - \frac{1}{3^2}\right]e = eV$$

$$\frac{13.6 \times 8}{9} = V$$

$$V = 12.09V \approx 12.1V$$

So, $\alpha = 121$

Question6

The ratio of the magnitude of the kinetic energy to the potential energy

of an electron in the 5^{th} excited state of a hydrogen atom is :
[30-Jan-2024 Shift 1]

Options:

A. 4

B. $\frac{1}{4}$

C. $\frac{1}{2}$

D. 1

Answer: C

Solution:

$\frac{1}{2}\left|PE\right| = KE$ for each value of n (orbit)

$\therefore \frac{KE}{|PE|} = \frac{1}{2}$

Question7

The ratio of the magnitude of the kinetic energy to the potential energy of an electron in the 5^{th} excited state of a hydrogen atom is :
[30-Jan-2024 Shift 1]

Options:

A. 4

B. $\frac{1}{4}$

C. $\frac{1}{2}$

D. 1

Answer: C

Solution:

Question8

A electron of hydrogen atom on an excited state is having energy $E_n = -0.85$ eV. The maximum number of allowed transitions to lower

energy level is ....
[30-Jan-2024 Shift 1]

Answer: 6

Solution:

$$E_n = -\frac{13.6}{n^2} = -0.85$$

$$\Rightarrow n = 4$$

No of transition

$$= \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$$

Question9

An electron revolving in n th Bohr orbit has magnetic moment μ_n. If $\mu_n \alpha n^x$, the value of x is:
[30-Jan-2024 Shift 2]

Options:

A. 2

B. 1

C. 3

D. 0

Answer: B

Solution:

Magnetic moment $= i\pi r^2$

$$\mu = \frac{evr}{2}$$

$$\mu \propto \left(\frac{1}{n}\right)n^2$$

$$\mu \propto n$$

$$x = 1$$

Question10

The mass defect in a particular reaction is 0.4g. The amount of energy liberated is $n \times 10^7$ kWh, where n = ______(speed of light $= 3 \times 10^8 m / s$)
[31-Jan-2024 Shift 1]

Answer: 1

Solution:

$E = \Delta mc^2$

$= 0.4 \times 10^{-3} \times (3 \times 10^8)^2$

$= 3600 \times 10^7$ kWs

$= \frac{3600 \times 10^7}{3600}$ kWh $= 1 \times 10^7$ kWh

Question11

In a nuclear fission process, a high mass nuclide (A ≈ 236) with binding energy 7.6 MeV/Nucleon dissociated into middle mass nuclides (A ≈ 118), having binding energy of 8.6 MeV / Nucleon. The energy released in the process would be_____ MeV.
[27-Jan-2024 Shift 1]

Answer: 236

Solution:

$Q = BE_{Product} - BE_{Rectant}$

$= 2(118)(8.6) - 236(7.6)$

$= 236 \times 1 = 236$ MeV

Question12

The atomic mass of ${}_6C^{12}$ is 12.000000u and that of ${}_6C^{13}$ is 13.003354u. The required energy to remove a neutron from ${}_6C^{13}$, if mass of neutron is 1.008665u, will be :
[27-Jan-2024 Shift 2]

Options:

A. 62.5 MeV

B. 6.25 MeV

C. 4.95 MeV

D. 49.5 MeV

Answer: C

Solution:

$${}_6C^{13} + \text{ Energy } \longrightarrow {}_6C^{12} + {}_0n^1$$

$$\Delta m = (12.000000 + 1.008665) - 13.003354 = -0.00531u$$

$$\therefore \text{ Energy required } = 0.00531 \times 931.5\,\text{MeV} = 4.95\,\text{MeV}$$

Question13

The explosive in a Hydrogen bomb is a mixture of ${}_1H^2$, ${}_1H^3$ and ${}_3Li^6$ in some condensed form. The chain reaction is given by
${}_3Li^6 + {}_0n^1 \rightarrow {}_2He^4 + {}_1H^3$
${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0n^1$
During the explosion the energy released is approximately
[Given : M(Li) = 6.01690 amu . M(${}_1H^2$) = 2.01471 amu.
M(${}_2He^4$) = 4.00388 amu, and 1 amu = 931.5 MeV]
[29-Jan-2024 Shift 1]

Options:

A. 28.12 MeV

B. 12.64 MeV

C. 16.48 MeV

D. 22.22 MeV

Answer: D

Solution:

$_3Li^6 + {}_0n^1 \longrightarrow {}_2He^4 + {}_1H^3$

${}_1H^2 + {}_1H^3 \longrightarrow {}_2He^4 + {}_0n^1$

$_3Li^6 + {}_1H^2 \longrightarrow 2({}_2He^4)$

Energy released in process

$Q = \Delta mc^2$

$Q = [M(Li) + M({}_1H^2) - 2 \times M({}_2He^4)] \times 931.5\,MeV$

$Q = [6.01690 + 2.01471 - 2 \times 4.00388] \times 931.5\,MeV$

$Q = 22.216\,MeV$

$Q = 22.22\,MeV$

Question14

In a nuclear fission reaction of an isotope of mass M , three similar daughter nuclei of same mass are formed. The speed of a daughter nuclei in terms of mass defect ΔM will be :
[30-Jan-2024 Shift 2]

Options:

A. $\sqrt{\frac{2c\,\Delta M}{M}}$

B. $\frac{\Delta Mc^2}{3}$

C. $c\sqrt{\frac{2\,\Delta M}{M}}$

D. $c\sqrt{\frac{3\,\Delta M}{M}}$

Answer: C

Solution:

$\underset{M}{(X)} \longrightarrow \underset{M/3}{(Y)} + \underset{M/3}{(Z)} + \underset{M/3}{(P)}$

$\Delta Mc^2 = \frac{1}{2}\frac{M}{3}V^2 + \frac{1}{2}\frac{M}{3}V^2 + \frac{1}{2}\frac{M}{3}V^2$

$V = c\sqrt{\frac{2\,\Delta M}{M}}$

Question15

The mass number of nucleus having radius equal to half of the radius of

nucleus with mass number 192 is:
[31-Jan-2024 Shift 2]

Options:

A. 24

B. 32

C. 40

D. 20

Answer: A

Solution:

$R_1 = \frac{R_2}{2}$

$R_0(A_1)^{1/3} = \frac{R_0}{2}(A_2)^{1/3}$

$A_1 = \frac{1}{8}A_2$

$A_1 = \frac{192}{8} = 24$

Question16

A nucleus has mass number A_1 and volume V_1. Another nucleus has mass number A_2 and volume V_2. If relation between mass number is $A_2 = 4A_1$, then $\frac{V_2}{V_1}$ = ____
[31-Jan-2024 Shift 2]

Answer: 4

Solution:

For a nucleus

Volume:

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

$R = R_0(A)^{1/3}$

$V = \frac{4}{3}\pi R_0{}^3 A$

$\Rightarrow \frac{V_2}{V_1} = \frac{A_2}{A_1} = 4$

Question17

The minimum energy required by a hydrogen atom in ground state to emit radiation in Balmer series is nearly :
[1-Feb-2024 Shift 1]

Options:

A. 1.5 eV

B. 13.6 eV

C. 1.9 eV

D. 12.1 eV

Answer: D

Solution:

Transition from n = 1 to n = 3
$\Delta E = 12.1 eV$

Question18

A particular hydrogen - like ion emits the radiation of frequency 3×10^{15} Hz when it makes transition from n = 2 to n = 1. The frequency of radiation emitted in transition from n = 3 to n = 1 is $\frac{x}{9} \times 10^{15}$ Hz, when x = _____
[1-Feb-2024 Shift 2]

Answer: 32

Solution:

$$E = -13.6z^2\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

$$E = C\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$h\nu = C\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$\frac{v_1}{v_2} = \frac{\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]_{2-1}}{\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]_{3-1}}$$

$$= \frac{\left[\frac{1}{1} - \frac{1}{4}\right]}{\left[\frac{1}{1} - \frac{1}{9}\right]} = \frac{3/4}{8/9}$$

$$= \frac{3}{4} \times \frac{9}{8}$$

$$\frac{v_1}{v_2} = \frac{27}{32}$$

$$v_2 = \frac{32}{27} v_1 = \frac{32}{27} \times 3 \times 10^{15}\,\text{Hz} = \frac{32}{9} \times 10^{15}\,\text{Hz}$$

Question19

The radius of a nucleus of mass number 64 is 4.8 fermi. Then the mass number of another nucleus having radius of 4 fermi is $\frac{1000}{x}$, where x is_____
[1-Feb-2024 Shift 1]

Answer: 27

Solution:

$$R = R_0 A^{1/3}$$

$$R^3 \propto A$$

$$\left(\frac{4.8}{4}\right)^3 = \frac{64}{A}$$

$$= \frac{64}{A} = (1.2)^3$$

$$\frac{64}{A} = 1.44 \times 1.2$$

$$A = \frac{64}{1.44 \times 1.2} = \frac{1000}{x}$$

$$x = \frac{144 \times 12}{64} = 27$$

Question20

From the statements given below :
(A) The angular momentum of an electron in n^{th} orbit is an integral multiple of h.
(B) Nuclear forces do not obey inverse square law.
(C) Nuclear forces are spin dependent.
(D) Nuclear forces are central and charge independent.
(E) Stability of nucleus is inversely proportional to the value of packing fraction.
Choose the correct answer from the options given below :
[1-Feb-2024 Shift 2]

Options:

A. (A), (B), (C), (D) only

B. (A), (C), (D), (E) only

C. (A), (B), (C), (E) only

D. (B), (C), (D), (E) only

Answer: C

Solution:

Solution:
Part of theory

Question21

If the binding energy of ground state electron in a hydrogen atom is 13.6 eV, then, the energy required to remove the electron from the second excited state of Li^{2+} will be: $x \times 10^{-1}$ eV. The value of x is ______ .
[31-Jan-2023 Shift 2]

Answer: 136

Solution:

$E_H = 13.6$

$E_{Li^{2+}} = 13.6\frac{Z^2}{n^2} = 13.6 \times \frac{9}{9} = 13.6\,\text{eV}$

$= 136 \times 10^{-1}\,\text{eV}$

Question22

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 A_6 are given by :
[24-Jan-2023 Shift 1]

Options:

A. 210 and 82

B. 210 and 84

C. 210 and 80

D. 211 and 80

Answer: C

Solution:

$$_{84}^{218}A \xrightarrow{\alpha} {}_{82}^{214}A_1 \xrightarrow{\beta^-} {}_{83}^{214}A_2 \xrightarrow{\gamma} {}_{83}^{214}A_3$$
$$_{83}^{214}A_3 \xrightarrow{\alpha} {}_{81}^{210}A_4 \xrightarrow{\beta^+} {}_{80}^{210}A_5 \xrightarrow{\gamma} {}_{80}^{210}A_6$$

Question23

The energy released per fission of nucleus of ^{240}X is 200 MeV. The energy released if all the atoms in 120g of pure ^{240}X undergo fission is ____ $\times 10^{25}$ MeV.
(. Given $N_A = 6 \times 10^{23}$)
[24-Jan-2023 Shift 2]

Answer: 0

Solution:

No. of mole $= \frac{120}{240} = \frac{1}{2}$

No. of molecules $= \frac{1}{2} \times N_A$

Energy released $= \frac{1}{2} \times 6 \times 10^{23} \times 200$

$= 6 \times 10^{25}$ MeV

Question24

The ratio of the density of oxygen nucleus ($_{8}^{16}O$) and helium nucleus ($_{2}^{4}He$) is
[25-Jan-2023 Shift 1]

Options:

A. 4 : 1

B. 8 : 1

C. 1 : 1

D. 2 : 1

Answer: C

Solution:

Solution:
Nuclear density is independent of mass number

As nuclear density $= \dfrac{Au}{\frac{4}{3}\pi R^3}$

Also, $R = R_0 A^{\frac{1}{3}}$

And $R^3 = R_0{}^3 A$

$\Rightarrow$ Nuclear density $= \dfrac{Au}{\frac{4}{3}\pi R_0{}^3 A}$

Nuclear density $= \dfrac{3u}{4\pi R_0{}^3}$

$\Rightarrow$ Nuclear density is independent of A

Question25

If a radioactive element having half-life of 30 min is undergoing beta decay, the fraction of radioactive element remains undecayed after 90 min. will be :
[29-Jan-2023 Shift 1]

Options:

A. $\frac{1}{8}$

B. $\frac{1}{16}$

C. $\frac{1}{4}$

D. $\frac{1}{2}$

Answer: A

Solution:

Solution:

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t\frac{1}{2}} = \left(\frac{1}{2}\right)^{\frac{90}{30}}$$

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

Question26

A radioactive element $^{242}_{92}X$ emits two α-particles, one electron and two positrons. The product nucleus is represented by $^{234}_{P}Y$. The value of P is ________

[29-Jan-2023 Shift 1]

Answer: 87

Solution:

Solution:

$P = 92 - 2 - 2 + 1 - 1 - 1$

$P = 92 - 5$

$P = 87$

Question27

Substance A has atomic mass number 16 and half life of 1 day. Another substance B has atomic mass number 32 and half life of $\frac{1}{2}$ day. If both A and B simultaneously start undergo radio activity at the same time with initial mass 320g each, how many total atoms of A and B combined would be left after 2 days.
[29-Jan-2023 Shift 2]

Options:

A. 3.38×10^{24}

B. 6.76×10^{24}

C. 6.76×10^{23}

D. 1.69×10^{24}

Answer: A

Solution:

Solution:

$(N_0)A = \frac{320}{16} = 20$ moles

$(N_0)B = \frac{320}{32} = 10$ moles

$N_A = \frac{(N_0)_A}{(2)^{2/1}} = \frac{20}{4} = 5$

$N_B = \frac{(N_0)_B}{(2)^{2/.5}} = \frac{10}{2^4} = 0.625$

Total $N = 5.625$

No. of atoms $= 5.625 \times 6.023 \times 10^{23}$

$= 3.38 \times 10^{24}$

Question28

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.
Assertion A : The nuclear density of nuclides $_5^{10}B$, $_3^6Li$, $_{26}^{56}Fe$, $_{10}^{20}Ne$ and $_{83}^{209}Bi$ can be arranged as $\rho_{Bi}^N > \rho_{Fe}^N > \rho_{Ne}^N > \rho_B^N > \rho_{Li}^N$.
Reason R : The radius R of nucleus is related to its mass number A as $R = R_0A^{1/3}$, where R_0 is a constant.
In the light of the above statement, choose the correct answer from the options given below :
[30-Jan-2023 Shift 2]

Options:

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

B. A is false but R is true

C. A is true but R is false

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

Answer: B

Solution:

Solution:
Nuclear density is independent of A.

Question29

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 30 s. The effective half-life of the nucleus is calculated to be $\frac{\alpha}{11}$ s. The value of α is _______.
[30-Jan-2023 Shift 2]

Answer: 300

Solution:

$\frac{dN_1}{dt} = -\lambda_1 N \quad \frac{dN_2}{dt} = -\lambda_2 N$

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

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

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

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

Question30

A free neutron decays into a proton but a free proton does not decay into neutron. This is because
[31-Jan-2023 Shift 1]

Options:

A. neutron is an uncharged particle

B. proton is a charged particle

C. neutron is a composite particle made of a proton and an electron

D. neutron has larger rest mass than proton

Answer: D

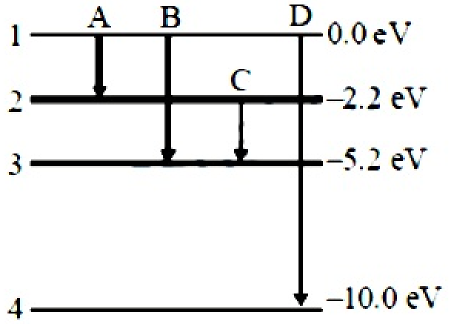
Solution:

Solution:
As neutron has more rest mass than proton it will require energy to decay proton into neutron.
Option 4.

Question31

The energy levels of an atom is shown is figure. Which one of these

transitions will result in the emission of a photon of wavelength 124.1 nm ? Given ($h = 6.62 \times 10^{-34}$ Js)



[25-Jan-2023 Shift 2]

Options:

A. B

B. A

C. C

D. D

Answer: D

Solution:

$\lambda = \frac{hc}{\Delta E}$

$\Delta E_A = 2.2 \text{ eV}$

$\Delta E_B = 5.2 \text{ eV}$

$\Delta E_C = 3 \text{ eV}$

$\Delta E_D = 10 \text{ eV}$

$\lambda_A = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{2.2 \times 1.6 \times 10^{-19}}$

$= \frac{12.41 \times 10^{-7}}{2.2} \text{m}$

$= \frac{1241}{2.2} \text{ nm} = 564 \text{ nm}$

$\lambda_B = \frac{1241}{5.2} \text{ nm} = 238.65 \text{ nm}$

$\lambda_C = \frac{1241}{3} \text{ nm} = 413.66 \text{ nm}$

$\lambda_D = \frac{1241}{10} = 124.1 \text{ nm}$

Question32

Speed of an electron in Bohr's 7^{th} orbit for Hydrogen atom is 3.6×10^6 m / s. The corresponding speed of the electron in 3^{rd} orbit, in m / s is :

[30-Jan-2023 Shift 1]

Options:

A. (1.8×10^6)

B. (7.5×10^6)

C. (3.6×10^6)

D. (8.4×10^6)

Answer: D

Solution:

$$V_n \propto \frac{Z}{n}$$

$$Z = 1, \therefore V_n \propto \frac{1}{n}$$

$$\therefore \frac{V_3}{V_7} = \frac{7}{3}$$

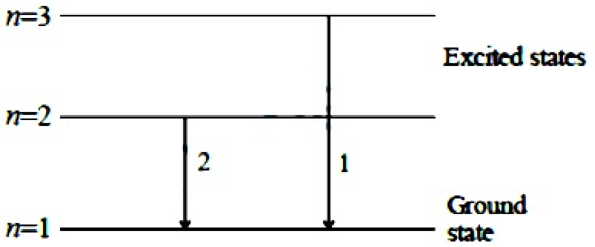
$$\therefore V_3 = \frac{7}{3} V_7$$

$$= \frac{7}{3} \times 3.6 \times 10^6 \text{m / s}$$

$$= 8.4 \times 10^6 \text{m / s}$$

Question33

For hydrogen atom, λ_1 and λ_2 are the wavelengths corresponding to the transitions 1 and 2 respectively as shown in figure. The ratio of λ_1 and λ_2 is $\frac{x}{32}$. The value of x is _______.



[31-Jan-2023 Shift 1]

Answer: 27

Solution:

$$\frac{1}{\lambda} = Rz^2 \left[\frac{1}{n_1{}^2} - \frac{1}{n_2{}^2} \right]$$

$$\frac{1}{\lambda_1} = Rz^2 \left[\frac{1}{1^2} - \frac{1}{3^2} \right] = \frac{8}{9} Rz^2 \ldots (1)$$

$$\frac{1}{\lambda_2} = Rz^2 \left[\frac{1}{1^2} - \frac{1}{2^2} \right] = \frac{3}{4} Rz^2 \ldots (2)$$

$$1 / 2 \Rightarrow \frac{\lambda_2}{\lambda_1} = \frac{8}{9} \times \frac{4}{3} = \frac{32}{27}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{27}{32}$$

Ans. 27

Question34

The radius of electron's second stationary orbit in Bohr's atom is R. The radius of 3 rd orbit will be
[31-Jan-2023 Shift 2]

Options:

A. 2.25R

B. 3R

C. $\frac{R}{3}R$

D. 9R

Answer: B

Solution:

$$r \propto \frac{n^2}{Z}$$

$$\frac{r_{2nd}}{r_{3rd}} = \left(\frac{n_2}{n_3}\right)^2$$

$$\Rightarrow \frac{R}{r_{3rd}} = \left(\frac{2}{3}\right)^2$$

$$\Rightarrow r_{3rd} = \frac{9}{4}R$$

$$= 2.25R$$

Question35

Assume that protons and neutrons have equal masses. Mass of a nucleon is 1.6×10^{-27} kg and radius of nucleus is $1.5 \times 10^{-15}A^{1/3}$m. The approximate ratio of the nuclear density and water density is $n \times 10^{13}$. The value of n is____
[24-Jan-2023 Shift 1]

Answer: 11

Solution:

$$\text{density of nuclei} = \frac{\text{mass of nuclei}}{\text{volume of nuclei}}$$

$$\rho = \frac{1.6 \times 10^{-27} A}{\frac{4}{3}\pi (1.5 \times 10^{-15})^3 A}$$

$$= \frac{1.6 \times 10^{-27}}{14.14 \times 10^{-45}} = 0.113 \times 10^{18}$$

$$\rho_w = 10^3$$

$$\frac{\rho}{\rho_w} = 11.31 \times 10^{13}$$

Question36

A photon is emitted in transition from n = 4 to n = 1 level in hydrogen atom. The corresponding wavelength for this transition is (given, h = 4×10^{-15} eVs) :
[24-Jan-2023 Shift 2]

Options:

A. 94.1 nm

B. 941 nm

C. 97.4 nm

D. 99.3 nm

Answer: A

Solution:

$$\frac{hc}{\lambda} = \left[1 - \frac{1}{16}\right](13.6\,\text{eV})$$

So, $\lambda = 94.1$ nm

Question37

The wavelength of the radiation emitted is λ_0 when an electron jumps from the second excited state to the first excited state of hydrogen atom. If the electron jumps from the third excited state to the second orbit of the hydrogen atom, the wavelength of the radiation emitted will be 20 / xλ_0. The value of x is _______.
[25-Jan-2023 Shift 1]

Answer: 27

Solution:

___________n=4
___________n=3
___________ n=2
___________n=1
Second excited state → first excited state
$n = 3 \rightarrow n = 2$
$\frac{hc}{\lambda_0} = 13.6\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \ldots (i)$
Third excited state → second orbit
$n = 4 \rightarrow n = 2$
$\frac{hc}{(20\lambda_0 / x)} = 13.6\left(\frac{1}{2^2} - \frac{1}{4^2}\right). \quad \ldots (ii)$
(ii) ÷ (i)
$$\frac{x}{20} = \frac{\frac{1}{2^2} - \frac{1}{4^2}}{\frac{1}{2^2} - \frac{1}{3^2}}$$
$x = 27$

Question38

The mass of proton, neutron and helium nucleus are respectively 1.0073u, 1.0087u and 4.0015u. The binding energy of helium nucleus is: [1-Feb-2023 Shift 1]

Options:

A. 14.2 MeV

B. 28.4 MeV

C. 56.8 MeV

D. 7.1 MeV

Answer: B

Solution:

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

Question39

A light of energy 12.75 eV is incident on a hydrogen atom in its ground state. The atom absorbs the radiation and reaches to one of its excited states. The angular momentum of the atom in the excited state is $\frac{x}{\pi} \times 10^{-17}$ eVs. The value of x is _______ (use $h = 4.14 \times 10^{-15}$ eVs, $c = 3 \times 10^8$ ms^{-1})

[1-Feb-2023 Shift 1]

Answer: 828

Solution:

In the ground state energy $= -13.6\,\text{eV}$
So energy

$$\frac{-13.6\,\text{eV}}{n^2} = -13.6 + 12.75$$

$$\frac{-13.6\,\text{eV}}{n^2} = -0.85$$

$$n = \sqrt{16}$$

$$n = 4$$

$$\text{Angular momentum} = \frac{nh}{2\pi} = \frac{4h}{2\pi} = \frac{2h}{\pi}$$

$$\text{Angular momentum} = \frac{2}{\pi} \times 4.14 \times 10^{-15}$$

$$= \frac{828 \times 10^{-17}}{\pi}\,\text{eVs}$$

Question40

An electron of a hydrogen like atom, having $Z = 4$, jumps from 4^{th} energy state to 2^{nd} energy state, The energy released in this process, will be:
(Given Rch = 13.6 eV)
Where R = Rydberg constant
c = Speed of light in vacuum
h = Planck's constant
[1-Feb-2023 Shift 2]

Options:

A. 13.6 eV

B. 10.5 eV

C. 3.4 eV

D. 40.8 eV

Answer: D

Solution:

$$\Delta E = 13.6Z^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right]\text{eV}$$

$$= 13.6 \times (4)^2\left(\frac{1}{4} - \frac{1}{16}\right)\text{eV}$$

$= 13.6[4 - 1]\,\text{eV}$
$= 13.6 \times 3 = 40.8\,\text{eV}$

Question41

Nucleus a having $Z = 17$ and equal number of protons and neutrons has $1.2\,\text{MeV}$ binding energy per nucleon.
Another nucleus B of $Z = 12$ has total 26 nucleons and $1.8\,\text{MeV}$ binding energy per nucleons.
The difference of binding energy of B and A will be _______ MeV.
[1-Feb-2023 Shift 2]

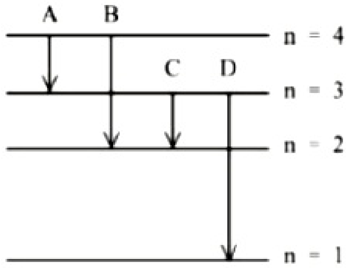
Answer: 6

Solution:

For A mass number $= 34$
Total binding energy $= 1.2 \times 34 = 40.8\,\text{MeV}$
For B mass number $= 26$
total binding energy $= 1.8 \times 26\,\text{MeV}$
$= 46.8\,\text{MeV}$
Difference of $\text{BE} = 6\,\text{MeV}$

Question42

The energy levels of an hydrogen atom are shown below. The transition corresponding to emission of shortest wavelength is



[6-Apr-2023 shift 1]

Options:

A. A

B. D

C. C

D. B

Answer: B

Solution:

$E = \frac{hc}{\lambda}$

$\Rightarrow \lambda = \frac{hc}{E}$

For λ_{min}, E must be maximum. And E is maximum for D.

Question43

The radius of fifth orbit of the $Li^{++}$is _______ $\times 10^{-12}$m Take : radius of hydrogen atom $= 0.5\overline{1}Å$
[6-Apr-2023 shift 1]

Answer: 425

Solution:

$r_n = \frac{0.51n^2}{z} A^0$

For Li^{++}, z = 3.

So $r_5 = 0.51 \times \frac{25}{3} \times 10^{-10}m = 17 \times 25 \times 10^{-12}m = 425 \times 10^{-12}m$

Question44

The ratio of wavelength of spectral lines H_α and H_β in the Balmer series is $\frac{x}{20}$. The value of x is
[8-Apr-2023 shift 2]

Answer: 27

Solution:

Question45

The angular momentum for the electron in Bohr's orbit is L. If the electron is assumed to revolve in second orbit of hydrogen atom, them the change in angular momentum will be
[10-Apr-2023 shift 1]

Options:

A. $\frac{L}{2}$

B. zero

C. L

D. 2L

Answer: C

Solution:

Solution:

Angular momentum $= \frac{nh}{2\pi}$

$n = 1, L_1 = \frac{h}{2\pi} = L$

$n = 2, L_2 = \frac{2h}{2\pi} = 2L$

$\Delta L = 2L - L = L$

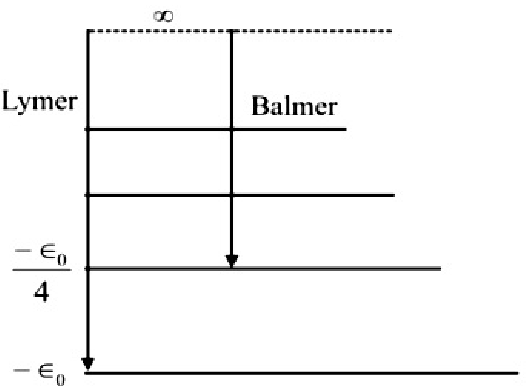
Question46

If 917Å be the lowest wavelength of Lyman series then the lowest wavelength of Balmer series will be _______ Å [10-Apr-2023 shift 2]

Answer: 3668

Solution:

Solution:



Lowest wavelength of by may sense will be obtained for trasition $n = \infty \rightarrow n = 1$
and for balmer series, Lyman Series $n = \infty \rightarrow n = 2$

for Lyman, $E_0 = \frac{hC}{917Å}$

for balmer, $\frac{E_0}{4} = \frac{hC}{\lambda(Å)}$

using this

$\lambda = 917 \times 4 = 3668$

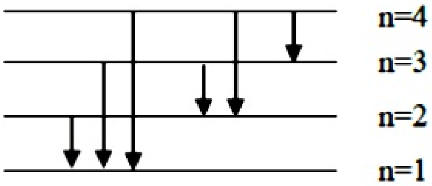
Question47

A monochromatic light is incident on a hydrogen sample in ground state. Hydrogen atoms absorb a fraction of light and subsequently emit radiation of six different wavelengths. The frequency of incident light is $x \times 10^{15}$ Hz. The value of x is ________.
(Given $h = 4.25 \times 10^{-15}$ eVs)
[11-Apr-2023 shift 1]

Answer: 3

Solution:

Solution:



Total emission lines = 6 (given)

So electron absorbed energy and jump from n = 1 to n = 4

$\Delta E 13.6\left[\frac{\ell}{\ell^2} - \frac{1}{4^2}\right]$ ev

$= 13.6\left[1 - \frac{1}{16}\right]$ ev

$\Delta E = hf$

$12.75 = 4.5 \times 10^{-15}$,

$f = \frac{12.75}{4.25} \times 10^{15} = 3 \times 10^{15}$ Hz

x = 3 Ans.

Question48

The energy of He^{+} ion in its first excited state is, (The ground state energy for the Hydrogen atom is −13.6 eV):
[11-Apr-2023 shift 2]

Options:

A. −13.6 eV

B. −54.4 eV

C. $-27.2\,\text{eV}$

D. $-3.4\,\text{eV}$

Answer: D

Solution:

Solution:

$$E = -\left(\frac{13.6z^2}{n^2}\right)\text{eV}$$

First excited state

$n = 2$

$$E = \frac{-13.6 \times z^2}{2^2} = -13.6\,\text{eV}$$

Question49

A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. The number of spectral lines emitted will be : [12-Apr-2023 shift 1]

Options:

A. 2

B. 3

C. 4

D. 1

Answer: B

Solution:

Solution:

$$12.5 = -13.6\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] \quad ni = 1$$

$$12.5 = -13.6\left[\frac{1}{n_f^2} - 1\right]$$

$$12.5 = 13.6 - \frac{13.6}{n_f^2}$$

$$-1.1 = -\frac{13.6}{n_f^2}$$

$n_f = 3.5$

$n_f = 3$ so transition is 3 to 1

No. of lines $= {}^3C_2 \left({}^nC_r = \frac{xn}{x|n-r)\,|\,xr}\right)$

$$= \frac{3}{(3-2)(2)}$$

$$\frac{3 \times 2 \times 1}{1 \times 2} = 3 \text{ lines}$$

Question50

The radius of 2^{nd} orbit of He^+ of Bohr's model is r_1 and that of fourth orbit of Be^{3+} is represented as r_2. Now the ratio $\frac{r_2}{r_1}$ is x : 1. The value of x is ___________
[13-Apr-2023 shift 1]

Answer: 2

Solution:

$$r \propto \frac{n^2}{Z}$$

$$\frac{r_2}{r_1} = \left(\frac{n_2}{n_1} \right)^2 \times \frac{z_1}{z_2}$$

$$\frac{r_2}{r_1} = \left(\frac{4}{2} \right)^2 \times \frac{2}{4}$$

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

$x = 2$

Question51

An atom absorbs a photon of wavelength 500 nm and emits another photon of wavelength 600 nm. The net energy absorbed by the atom in this process is $n \times 10^{-4}$ eV. The value of n is [Assume the atom to be stationary during the absorption and emission process] (. Take $h = 6.6 \times 10^{-34}$ Js and $c = 3 \times 10^8 m/s$)
[13-Apr-2023 shift 2]

Answer: 4125

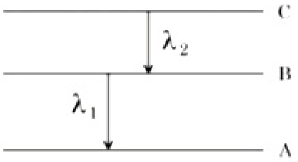
Solution:

$$E = E_1 - E_2 = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2} \right)$$

$E = 6.6 \times 10^{-20} J$
$E = 4.125 \times 10^{-1}$ eV
$E = 4125 \times 10^{-4}$ eV

Question52

As per given figure A, B and C are the first, second and third excited energy levels of hydrogen atom respectively. If the ratio of the two wavelengths (. i.e. $\frac{\lambda_1}{\lambda_2}$) is $\frac{7}{4n}$, then the value of n will be ________.



[15-Apr-2023 shift 1]

Answer: 5

Solution:

For A, n = 2
B, n = 3
C, n = 4

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda_2} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$

$$\frac{1}{\lambda_2} = \frac{7R}{144} \ldots (1)$$

$$\frac{1}{\lambda_1} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\frac{1}{\lambda_1} = \frac{5R}{36} \ldots (2)$$

(1) and (2)

$$\frac{\lambda_1}{\lambda_2} = \frac{7}{20} = \frac{7}{4 \times 5}$$

n = 5

Question53

For a nucleus ${}_Z^AX$ having mass number A and atomic number Z

A. The surface energy per nucleon (b_s) = $-a_1A^{2/3}$.

B. The Coulomb contribution to the binding energy $b_c = -a_2 \frac{Z(Z-1)}{A^{4/3}}$

C. The volume energy $b_v = a_3A$

D. Decrease in the binding energy is proportional to surface area.

E. While estimating the surface energy, it is assumed that each nucleon interacts with 12 nucleons. (a_1, $a_{2.}$ and a_3 are constants)

Choose the most appropriate answer from the options given below:

[8-Apr-2023 shift 1]

Options:

A. B, C only

B. A, B, C, D only

C. B, C, E only

D. C, D only

Answer: D

Solution:

Solution:

$$E_B = a_v A - a_s A^{2/3} - a_A \frac{(A-2Z)^2}{A^{1/3}} - a_c \frac{Z(Z-1)}{A^{1/3}} + \delta(A, Z)$$

Most appropriate is option (4)

Question54

A nucleus with mass number 242 and binding energy per nucleon as 7.6 MeV breaks into two fragment each with mass number 121. If each fragment nucleus has binding energy per nucleon as 8.1 MeV, the total gain in binding energy is ________ MeV.
[8-Apr-2023 shift 1]

Answer: 121

Solution:

Gain in binding energy $= B \cdot E_f - B_i$
$= 2(121 \times 8.1) - 242 \times 7.6$
$= 121\ \text{MeV}$

Question55

A radio active material is reduced to 1 / 8 of its original amount in 3 days. If 8×10^{-3} kg of the material is left after 5 days the initial amount of the material is
[8-Apr-2023 shift 2]

Options:

A. 64g

B. 40g

C. 32g

D. 256g

Answer: D

Solution:

$m = m_0 e^{-\lambda t}$

$\frac{m_0}{8} = m_0 e^{-\lambda t}$

$-\ln 8 = -\lambda t$

$= \lambda = \frac{\ln 8}{3}$ per day

$m = m_0 e^{-\lambda t}$

$8 = m_0 e^{-\frac{\ln 8}{3} \times 5}$

$\Rightarrow 8 = m_0 e^{-\frac{3 \ln 2}{3} \times 5}$

$8 = m_0 e^{\ln 2^{-5}}$

$= 8 m_0 \left(\frac{1}{2^5} \right)$

$m_0 = 8 \times 2^5$

$= 8 \times 32$

$m_0 = 256 gm^2$

Question56

The decay constant for a radioactive nuclide is $1.5 \times 10^{-5}\ s^{-1}$. Atomic weight of the substance is $60 gmole^{-1}$, ($N_A = 6 \times 10^{23}$). The activity of 1.0μg of the substance is _______ $\times 10^{10}$ Bq.
[10-Apr-2023 shift 1]

Answer: 15

Solution:

No. of moles $= \frac{1 \times 10^{-6}}{60} = \frac{10^{-7}}{6}$

No. of atom $= n(N A) = \frac{10^{-7}}{6} \times 6 \times 10^{23} = 10^{16}$

at $(t = 0) A_0 = No\,\lambda = 10^{16} \times 1.5 \times 10^{-5} = 15 \times 10^{10}$ Bq

----

Question57

The half life of a radioactive substance is T. The time taken, for disintegrating $\frac{7}{8}$ th part of its original mass will be:
[10-Apr-2023 shift 2]

Options:

A. T

B. 2T

C. 3T

D. 8T

Answer: C

Solution:

Solution:

If $\frac{7}{8}$ th is disintegrated it means only $\frac{1}{8}$ th part is radioactive active no. of nuclears after ' n ' half lives

$\Rightarrow \frac{N_o}{2^n} = \frac{N_o}{8}$

$2^n = 8 = n = 3$

So, the elapsed is 3 half lives $= 3T$

Question58

Two radioactive elements A and B initially have same number of atoms. The half life of A is same as the average life of B. If λ_A and λ_B are decay constants of A and B respectively, then choose the correct relation from the given options. [11-Apr-2023 shift 1]

Options:

A. $\lambda_A = 2\lambda_B$

B. $\lambda_A = \lambda_B$

C. $\lambda_A \ln 2 = \lambda_B$

D. $\lambda_A = \lambda_B \ln 2$

Answer: D

Solution:

	A		B	
				$T \rightarrow$ half life
$t = 0$	N_0		N_0	$\tau \rightarrow$ ang life
$T_A = \tau_B$		$\rightarrow$	given in question	

Now $\frac{\ln(2)}{\lambda_A} = \frac{1}{\lambda_B} \Rightarrow \lambda_A = \lambda_B \cdot \ln(2)$

Question59

A common example of alpha decay is
${}_{92}{}^{238}U \rightarrow {}_{90}{}^{234}Th + {}_{2}He^{4} + Q$
Given :
${}_{92}{}^{238}U = 238.05060u$,
${}^{234}Th = 234.04360u$,
90
${}_{2}{}^{4}He = 4.00260u$ and
$lu = 931.5\ \frac{MeV}{c^2}$
The energy released (Q) during the alpha decay of ${}^{238}U$ is _______ MeV
[12-Apr-2023 shift 1]

Answer: 4.25

Solution:

$\alpha = (m_u - M_{th} - M_{Ho})C^2$
$\alpha = 0.00456 \times 931.5$
$\alpha = 4.25\,MeV$

Question60

${}_{92}{}^{238}A \rightarrow {}_{90}{}^{234}B + {}_{2}{}^{4}D + Q$
In the given nuclear reaction, the approximate amount of energy released will be: [Given, mass of ${}_{92}{}^{238}A = 238.05079 \times 931.5\,MeV/c^2$,
mass of ${}_{90}{}^{234}B = 234.04363 \times 931.5\,MeV/c^2$,
mass of ${}_{2}{}^{4}D = 4.00260 \times 931.5\,MeV/c^2$]
[13-Apr-2023 shift 1]

Options:

A. $4.25\,MeV$

B. $5.9\,MeV$

C. $3.82\,MeV$

D. $2.12\,MeV$

Answer: A

Solution:

$Q = \Delta mC^2$
$Q = (238.05079 - 234.04363 - 4.00260) \times 931.5\,\text{MeV}$
$Q = 0.00456 \times 931.5\,\text{MeV}$
$Q = 4.25\,\text{MeV}$

Question61

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R
Assertion A : The binding energy per nucleon is practically independent of the atomic number for nuclei of mass number in the range 30 to 170 .
Reason R : Nuclear force is short ranged.
In the light of the above statements, choose the correct answer from the options given below
[13-Apr-2023 shift 2]

Options:

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

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

C. A is true but R is false

D. A is false but R is true

Answer: B

Solution:

Solution:

Question62

The half-life of a radioactive nucleus is 5 years. The fraction of the original sample that would decay in 15 years is :
[15-Apr-2023 shift 1]

Options:

A. $\frac{3}{4}$

B. $\frac{1}{8}$

C. $\frac{7}{8}$

D. $\frac{1}{4}$

Answer: C

Solution:

$$N = N_0\left(\frac{1}{2}\right)^{t/T_{/2}}$$

$$N = N_0\left(\frac{1}{2}\right)^{15/5}$$

$$N = \frac{N_0}{8}$$

$$\text{Decayed nuclei} = N_0 - \frac{N_0}{8}$$

$$= \frac{7N_0}{8}$$

Question63

**Choose the correct option from the following options given below :
In the ground state of Rutherford's model electrons are in stable equilibrium. While in Thomson's
[24-Jun-2022-Shift-1]**

Options:

A. model electrons always experience a net-force.
An atom has a nearly continuous mass distribution in a Rutherford's model but has a highly non-

B. uniform mass distribution in Thomson's model.

C. A classical atom based on Rutherford's model is doomed to collapse.

D. The positively charged part of the atom possesses most of the mass in Rutherford's model but not in Thomson's model.

Answer: C

Solution:

Solution:
An atom based on classical theory of Rutherford's model should collapse as the electrons in continuous circular motion that is a continuously accelerated charge should emit EM waves and so should lose energy. These electrons losing energy should soon fall into heavy nucleus collapsing the whole atom.

Question64

In Bohr's atomic model of hydrogen, let K, P and E are the kinetic energy, potential energy and total energy of the electron respectively. Choose the correct option when the electron undergoes transitions to a higher level :

[24-Jun-2022-Shift-2]

Options:

A. All K, P and E increase.

B. K decreases, P and E increase.

C. P decreases, K and E increase.

D. K increases, P and E decrease.

Answer: B

Solution:

Solution:

$T.E. = \frac{-Z^2 me^4}{8(nh\varepsilon_0)^2}$

$P.E. = \frac{-Z^2 me^4}{4(nh\varepsilon_0)^2}$

$K.E. = \frac{Z^2 me^4}{8(nh\varepsilon_0)^2}$

As electron makes transition to higher level, total energy and potential energy increases (due to negative sign) while the kinetic energy reduces.

Question65

The ratio for the speed of the electron in the 3^{rd} orbit of He^+ to the speed of the electron in the 3^{rd} orbit of hydrogen atom will be : [25-Jun-2022-Shift-1]

Options:

A. 1 : 1

B. 1 : 2

C. 4 : 1

D. 2 : 1

Answer: D

Solution:

Solution:

We know that $v \propto \frac{Z}{n}$

⇒ Required ratio $= \frac{\frac{2}{3}}{\frac{1}{3}}$

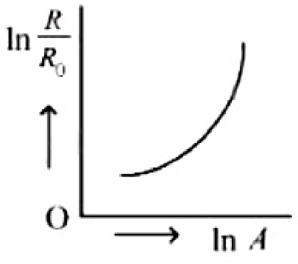
= 2 : 1

Question66

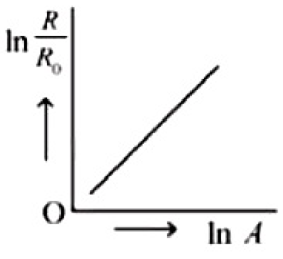
Which of the following figure represents the variation of $l_n\left(\frac{R}{R_0}\right)$ with l_nA (if R = radius of a nucleus and A = its mass number)
[25-Jun-2022-Shift-2]

Options:

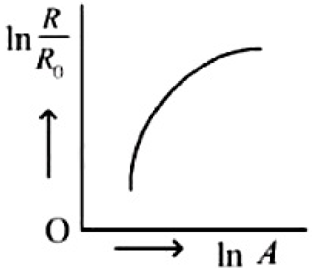
A.



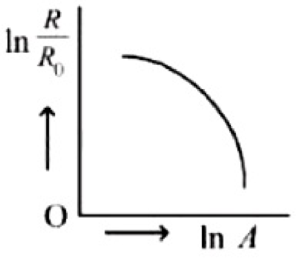
B.



C.



D.



Answer: B

Solution:

Solution:
We know that
$R = R_0A^{1/3}$

$$\Rightarrow \underbrace{\ln\left(\frac{R}{R_0}\right)}_{y} = \underbrace{\frac{1}{3}}_{m} \underbrace{\ln(A)}_{x}$$

⇒ Straight line

Question67

A hydrogen atom in its ground state absorbs 10.2 eV of energy. The angular momentum of electron of the hydrogen atom will increase by the value of :
(Given, Planck's constant $= 6.6 \times 10^{-34}$ Js).
[27-Jun-2022-Shift-1]

Options:

A. 2.10×10^{-34} JS

B. 1.05×10^{-34} Js

C. 3.15×10^{-34} Js

D. 4.2×10^{-34} Js

Answer: B

Solution:

Solution:

$$-13.6 + 10.2 = \frac{-13.6}{n^2}$$

$$\Rightarrow \frac{13.6}{n^2} = 3.4$$

$$\Rightarrow n = 2$$

$$\Rightarrow \Delta L = 2 \times \frac{h}{2\lambda} - 1 \times \frac{h}{2\lambda}$$

$$= \frac{h}{2\lambda}$$

$$\Rightarrow \Delta L \simeq 1.05 \times 10^{-34} \text{ Js}$$

Question68

A beam of monochromatic light is used to excite the electron in Li^{++} from the first orbit to the third orbit. The wavelength of monochromatic light is found to be $x \times 10^{-10}$ m. The value of x is____
[Given hc $= 1242$ eV nm]
[27-Jun-2022-Shift-1]

Answer: 114

Solution:

$$E(\in eV) = 13.6 \times 9\left(1 - \frac{1}{9}\right)$$
$$= 13.6 \times 8\,eV$$
$$\Rightarrow \lambda = \frac{12420}{13.6 \times 8}\,\overset{o}{A}$$
$$= 114.15\,\overset{o}{A}$$

Question69

$\sqrt{d_1}$ and $\sqrt{d_2}$ are the impact parameters corresponding to scattering angles 60° and 90° respectively, when an α particle is approaching a gold nucleus. For $d_1 = xd_2$, the value of x will be_____ [29-Jun-2022-Shift-1]

Answer: 3

Solution:

Impact parameter $\propto \cot\frac{\theta}{2}$

$$\Rightarrow \sqrt{\frac{d_1}{d_2}} = \frac{\sqrt{3}}{1}$$
$$\Rightarrow d_1 = 3d_2$$
$$\Rightarrow x = 3$$

Question70

Nucleus A is having mass number 220 and its binding energy per nucleon is 5.6 MeV. It splits in two fragments ' B ' and ' C ' of mass numbers 105 and 115 . The binding energy of nucleons in ' B ' and ' C ' is 6.4 MeV per nucleon. The energy Q released per fission will be : [24-Jun-2022-Shift-1]

Options:

A. 0.8 MeV

B. 275 MeV

C. 220 MeV

D. 176 MeV

Answer: D

Solution:

$^{220}A \rightarrow {}^{105}B + {}^{115}C$
$\Rightarrow Q = [105 \times 6.4 + 115 \times 6.4] - [220 \times 5.6]\,\text{MeV}$
$\Rightarrow Q = 176\,\text{MeV}$

Question71

A sample contains 10^{-2} kg each of two substances A and B with half lives 4s and 8 s respectively. The ratio of their atomic weights is 1 : 2. The ratio of the amounts of A and B after 16s is $\frac{x}{100}$. The value of x is_____
[24-Jun-2022-Shift-2]

Answer: 25

Solution:

$$N_1 = \frac{\left(\frac{10^{-2}}{1}\right)}{2^4}$$

$$N_2 = \frac{\left(\frac{10^{-2}}{2}\right)}{2^2}$$

$$\Rightarrow \frac{N_1}{N_2} = \frac{1}{2}$$

∴ Mass ratio of A and B,

$$\frac{m_1}{m_2} = \frac{N_1}{N_2} \times \left(\frac{M_1}{M_2}\right)$$

$$= \frac{1}{2} \times \left(\frac{1}{2}\right)$$

$$= \frac{1}{4}$$

$$= \frac{25}{100}$$

$\therefore x = 25$

Question72

How many alpha and beta particles are emitted when Uranium $_{92}U^{238}$ decays to lead $_{82}Pb^{206}$?
[26-Jun-2022-Shift-1]

Options:

A. 3 alpha particles and 5 beta particles

B. 6 alpha particles and 4 beta particles

C. 4 alpha particles and 5 beta particles

D. 8 alpha particles and 6 beta particles

Answer: D

Solution:

${}_{92}U^{238} \longrightarrow {}_{82}Pb^{206} + x({}_{2}He^{4}) + {}_{y}(-1\beta^{0})$
$238 = 206 + 4x + 0$
$\Rightarrow 4x = 32 \Rightarrow x = 8$
also, $92 = 82 + 2x - y$
$y = 82 + 16 - 92 = 6$

Question73

A radioactive nucleus can decay by two different processes. Half-life for the first process is 3.0 hours while it is 4.5 hours for the second process. The effective half-life of the nucleus will be:
[26-Jun-2022-Shift-2]

Options:

A. 3.75 hours

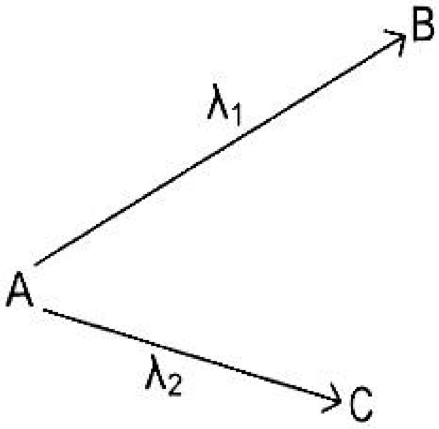
B. 0.56 hours

C. 0.26 hours

D. 1.80 hours

Answer: D

Solution:



$\frac{dA}{dt} - (-\lambda_1 A) + (-\lambda_2 A)$
$\Rightarrow \frac{dA}{dt} = -(\lambda_1 + \lambda_2)A$
$\Rightarrow \lambda_{eff} = \lambda_1 + \lambda_2$

$$\Rightarrow \frac{\ln 2}{(t_{1/2})_{eff}} = \frac{\ln 2}{(t_{1/2})_1} + \frac{\ln 2}{(t_{1/2})_2}$$
$$\Rightarrow (t_{1/2})_{eff} = \frac{4.5 \times 3}{7.5} \text{ hours } = 1.8 \text{ hours}$$

Question74

The Q-value of a nuclear reaction and kinetic energy of the projectile particle, K_p are related as :
[28-Jun-2022-Shift-1]

Options:

A. $Q = K_p$

B. $(K_p + Q) < 0$

C. $Q < K_p$

D. $(K_p + Q) > 0$

Answer: D

Solution:

Solution:
$K_p > 0$
If Q is released $\Rightarrow Q > 0$
$\Rightarrow K_p + Q > 0$
Even the particle has to be given kinetic energy greater than magnitude of Q to maintain momentum conservation.
$\Rightarrow K + Q > 0$

Question75

Following statements related to radioactivity are given below :
(A) Radioactivity is a random and spontaneous process and is dependent on physical and chemical conditions.
(B) The number of un-decayed nuclei in the radioactive sample decays exponentially with time.
(C) Slope of the graph of $\log_e$ (no. of undecayed nuclei) Vs. time represents the reciprocal of mean life time (τ).
(D) Product of decay constant (λ) and half-life time ($T_{1/2}$) is not constant.
Choose the most appropriate answer from the options given below :
[28-Jun-2022-Shift-2]

Options:

A. (A) and (B) only

B. (B) and (D) only

C. (B) and (C) only

D. (C) and (D) only

Answer: C

Solution:

Solution:
Radioactive decay is a random and spontaneous process it depends on unbalancing of nucleus.
$N = N_0 e^{-\lambda t}$..... (B)
$\ln N = -\lambda t + \ln N_0$
So, slope $= -\lambda$..... (C)
$t_{1/2} = \frac{\ln 2}{\lambda}$
So $t_{1/2} \times \lambda = \ln 2 =$ Constant

Question76

The activity of a radioactive material is 2.56×10^{-3} Ci. If the half life of the material is 5 days, after how many days the activity will become 2×10^{-5} Ci ?
[29-Jun-2022-Shift-1]

Options:

A. 30 days

B. 35 days

C. 40 days

D. 25 days

Answer: B

Solution:

$\frac{A}{A_0} = \frac{N}{N_0}$
$\frac{2 \times 10^{-5}}{2.56 \times 10^{-3}} = \frac{N}{N_0}$
$\frac{N}{N_0} = \frac{1}{128} \Rightarrow N = \frac{N_0}{128}$
After 7 half life activity comes down to given value $T = 7 \times 5$
$= 35$ days

Question77

In the following nuclear reaction,
$\mathbf{D \xrightarrow{\alpha} D_1 \xrightarrow{\beta^-} D_2 \xrightarrow{\alpha} D_3 \xrightarrow{\gamma} D_4}$

Mass number of D is 182 and atomic number is 74 . Mass number and atomic number of D_4 respectively will be____
[29-Jun-2022-Shift-2]

Options:

A. 174 and 71

B. 174 and 69

C. 172 and 69

D. 172 and 71

Answer: A

Solution:

Equivalent reaction can be written as
$D \longrightarrow D_4 + 2\alpha + \beta^- + \gamma$
$\Rightarrow$ Mass number of $D_4 =$ Mass number of $D - 2 \times 4$
$= 182 - 8 = 174$
$\Rightarrow$ Atomic number of D_4
$=$ Atomic number of $D - 2 \times 2 + 1$
$= 74 - 4 + 1 = 71$

Question78

The half life of a radioactive substance is 5 years. After x years a given sample of the radioactive substance gets reduced to 6.25% of its initial value. The value of x is____
[29-Jun-2022-Shift-2]

Answer: 20

Solution:

$N = N_0 e^{-\lambda t}$
$\Rightarrow \frac{6.25}{100} = e^{-\lambda t}$
$\Rightarrow e^{-\lambda t} = \frac{1}{16} = \left(\frac{1}{2}\right)^4$
$\Rightarrow t = 4t_{1/2}$
$\Rightarrow t = 20$ years

Question79

The momentum of an electron revolving in n^{th} orbit is given by: (Symbols have their usual meanings)
[25-Jul-2022-Shift-1]

Options:

A. $\frac{nh}{2\pi r}$

B. $\frac{nh}{2r}$

C. $\frac{nh}{2\pi}$

D. $\frac{2\pi r}{nh}$

Answer: A

Solution:

$\because mvr = \frac{nh}{2\pi}$

$\Rightarrow mv = \frac{nh}{2\pi r}$

Question80

The magnetic moment of an electron (e) revolving in an orbit around nucleus with an orbital angular momentum is given by :
[25-Jul-2022-Shift-1]

Options:

A. $\vec{\mu}_L = \frac{e\vec{L}}{2m}$

B. $\vec{\mu}_L = -\frac{e\vec{L}}{2m}$

C. $\vec{\mu}_l = -\frac{e\vec{L}}{m}$

D. $\vec{\mu}_l = \frac{2e\vec{L}}{m}$

Answer: B

Solution:

$\because \vec{\mu} = \frac{\vec{q}}{2m}$

$\Rightarrow \vec{\mu} = \frac{-e\vec{L}}{2m}$

Question81

Hydrogen atom from excited state comes to the ground state by emitting a photon of wavelength λ. The value of principal quantum number ' n ' of the excited state will be : (R : Rydberg constant)
[25-Jul-2022-Shift-2]

Options:

A. $\sqrt{\frac{\lambda R}{\lambda - 1}}$

B. $\sqrt{\frac{\lambda R}{\lambda R - 1}}$

C. $\sqrt{\frac{\lambda}{\lambda R. - 1}}$

D. $\sqrt{\frac{\lambda R^2}{\lambda R - 1}}$

Answer: B

Solution:

$\because \frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$

$\Rightarrow \frac{1}{\lambda R} = 1 - \frac{1}{n^2}$

$\Rightarrow \frac{1}{n^2} = 1 - \frac{1}{\lambda R} = \frac{\lambda R - 1}{\lambda R}$

$\Rightarrow n = \sqrt{\frac{\lambda R}{\lambda R - 1}}$

Question82

$\frac{x}{x+4}$ **is the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its**
(i) third permitted energy level to the second level and
(ii) the highest permitted energy level to the second permitted level.
The value of x will be
[25-Jul-2022-Shift-2]

Answer: 5

Solution:

$E_n = -\frac{13.6}{n^2}eV$

$\frac{\frac{1}{2^2} - \frac{1}{3^2}}{\frac{1}{2^2}} = \frac{x}{x+4}$

$\Rightarrow \frac{9-4}{9 \times 4 \times \frac{1}{4}} = \frac{x}{x+4} = \frac{5}{9}$

$x = 5$

Question83

In the hydrogen spectrum, λ be the wavelength of first transition line of Lyman series. The wavelength difference will be "a λ ' between the wavelength of 3^{rd} transition line of Paschen series and that of 2^{nd} transition line of Balmer series where a = _________.
[26-Jul-2022-Shift-1]

Answer: 5

Solution:

$\frac{1}{\lambda} = R_H\left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$\frac{1}{\lambda_3} = R_H\left(\frac{1}{3^2} - \frac{1}{6^2}\right)$

$\frac{1}{\lambda_2} = R_H\left(\frac{1}{2^2} - \frac{1}{4^2}\right)$

$\therefore \lambda_3 - \lambda_2 = a\lambda$

$a = 5$

Question84

A nucleus of mass M at rest splits into two parts having masses $\frac{M'}{3}$ and $\frac{2M'}{3}$($M' < M$). The ratio of de Broglie wavelength of two parts will be :
[26-Jul-2022-Shift-2]

Options:

A. 1 : 2

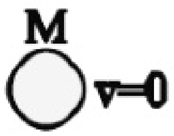
B. 2 : 1

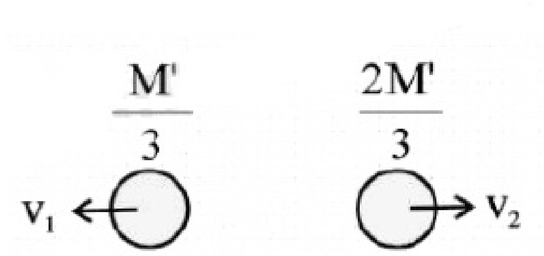
C. 1 : 1

D. 2 : 3

Answer: C

Solution:





$\left|\vec{P}_1\right| = \left|\vec{P}_2\right|$

Here $\vec{P}$ is momentum

So $\lambda = \frac{h}{P}$

Hence both will have same de broglie wavelength.

Question85

Mass numbers of two nuclei are in the ratio of 4 : 3. Their nuclear densities will be in the ratio of [26-Jul-2022-Shift-2]

Options:

A. 4 : 3

B. $\left(\frac{3}{4}\right)^{\frac{1}{3}}$

C. 1 : 1

D. $\left(\frac{4}{3}\right)^{\frac{1}{3}}$

Answer: C

Solution:

Solution:

Radius of nucleus $R = R_0 A^{\frac{1}{3}}$

Density of nucleus $= \frac{\text{Mass of nucleus}}{\text{volume of nucleus}}$

$\rho = \frac{m \times A}{\frac{4}{3}\pi R^3}$ Where m: mass of proton or neutron

$\rho = \frac{m \times A}{\frac{4}{3}\pi {R_0}^3 A}$

$\rho \propto A^0$

Hence density of nucleus is independent of mass number

Question86

An electron (mass m) with an initial velocity $\vec{v} = v_0 i (v_0 > 0)$ is moving in an electric field $\vec{E} = -E_0 \hat{i} (E_0 > 0)$ where E_0 is constant. If at t = 0 de Broglie wavelength is $\lambda_0 = \frac{h}{mv_0}$, then its de Broglie wavelength after time t is given by
[27-Jul-2022-Shift-1]

Options:

A. λ_0

B. $\lambda_0 \left(1 + \frac{eE_0 t}{mv_0}\right)$

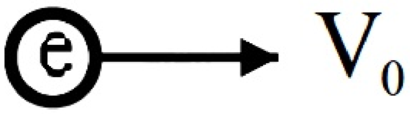
C. $\lambda_0 t$

D. $\frac{\lambda_0}{\left(1 + \frac{eE_0 t}{mv_0}\right)}$

Answer: D

Solution:

Solution:



$E = -E_0 \hat{i}$

$\lambda_0 = \frac{h}{mv}$

$v = v_0 + \frac{eE_0 t}{m}$

$\lambda = \frac{h}{mv} = \frac{h}{m\left(v_0 + \frac{eE_0}{m} t\right)}$

$\lambda' = \frac{h}{mv_0\left(1 + \frac{eE}{mv_0} t\right)}$

$\lambda' = \frac{\lambda_0}{\left(1 + \frac{eE_0}{mv_0} t\right)}$

Question87

Find the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its (i) second permitted energy level to the first level, and (ii) the highest permitted energy level to the first permitted level.
[29-Jul-2022-Shift-1]

Options:

A. 3 : 4

B. 4 : 3

C. 1 : 4

D. 4 : 1

Answer: A

Solution:

Solution:

$E_n = \frac{-13.6}{n^2} ev$

$\Rightarrow \frac{E_2 - E_1}{E_\infty - E_1} = \frac{13.6\left(1 - \frac{1}{4}\right)}{13.6} = \frac{3}{4}$

Question88

Read the following statements:
(A) Volume of the nucleus is directly proportional to the mass number.
(B) Volume of the nucleus is independent of mass number.
(C) Density of the nucleus is directly proportional to the mass number.
(D) Density of the nucleus is directly proportional to the cube root of the mass number.
(E) Density of the nucleus is independent of the mass number.
Choose the correct option from the following options.
[29-Jul-2022-Shift-2]

Options:

A. (A) and (D) only.

B. (A) and (E) only.

C. (B) and (E) only.

D. (A) and (C) only.

Answer: B

Solution:

We know,

Radius of nucleus, $r = r_0 A^{\frac{1}{3}}$

where, A = mass number

$\therefore$ Volume $(v) = \frac{4}{3}\pi r^3$

$= \frac{4}{3}\pi r_0{}^3 \cdot A$

$\therefore v \propto A$

∴ Volume is directly proportional to mass number.

We know,

$\text{density}(d) = \frac{m}{v}$

$= \frac{zm_p + (A - z)m_N}{\frac{4}{3}\pi r_0{}^3 (A^{1/3})^3}$

$= \frac{zm_p + Am_p - zm_p}{\frac{4}{3}\pi r_0{}^3 A} [\because m_p \simeq m_N]$

$= \frac{Am_p}{\frac{4}{3}\pi r_0{}^3 A}$

$= \frac{m_p}{\frac{4}{3}\pi r_0{}^3}$

∴ Density of nucleus is independent of mass number.

Question89

The disintegration rate of a certain radioactive sample at any instant is 4250 disintegrations per minute. 10 minutes later, the rate becomes 2250 disintegrations per minute. The approximate decay constant is : (Take $\log_{10} 1.88 = 0.274$)

[26-Jul-2022-Shift-1]

Options:

A. 0.02min^{-1}

B. 2.7min^{-1}

C. 0.063min^{-1}

D. 6.3min^{-1}

Answer: C

Solution:

$A_0 = 4250$

$A = 2250 = A_0 e^{-\lambda t}$

$\Rightarrow \frac{2250}{4250} = e^{-\lambda t}$

$\Rightarrow \lambda(10) = \ln\left(\frac{4250}{2250}\right)$

$\lambda(10) = 0.636$

$\lambda = 0.063$

Question90

Two lighter nuclei combine to form a comparatively heavier nucleus by the relation given below :
${}_{1}^{2}X + {}_{1}^{2}X = {}_{2}^{4}Y$
The binding energies per nucleon for ${}_{1}^{2}X$ and ${}_{2}^{4}Y$ are 1.1 MeV and 7.6 MeV respectively. The energy released in this process is ________ MeV
[26-Jul-2022-Shift-2]

Answer: 26

Solution:

Energy released in the given process = Binding energy of product - Binding energy of reactants
$= 7.6 \times 4 - (1.1 \times 2) \times 2$
$= 30.4 - 4.4$
$= 26\,\text{MeV}$

Question91

What is the half-life period of a radioactive material if its activity drops to $1/16^{\text{th}}$ of its initial value in 30 years?
[27-Jul-2022-Shift-1]

Options:

A. 9.5 years

B. 8.5 years

C. 7.5 years

D. 10.5 years

Answer: C

Solution:

$A = A_0 e^{-\lambda t}$

$\Rightarrow -\lambda t = \ln\left(\frac{A}{A_0}\right)$

$\Rightarrow -\frac{\ell n2}{t_{1/2}} \times 30 = \ell n\left(\frac{1}{16}\right)$

$\Rightarrow -\frac{\ell n2}{t_{1/2}} \times 30 = -4\ell n2$

$\Rightarrow t_{1/2} = \frac{30}{4} = 7.5\,\text{yrs}$

Question92

The activity of a radioactive material is 6.4×10^{-4} curie. Its half life is 5 days. The activity will become 5×10^{-6} curie after :
[27-Jul-2022-Shift-2]

Options:

A. 7 days

B. 15 days

C. 25 days

D. 35 days

Answer: D

Solution:

$A_0 = 6.4 \times 10^{-4}$ Curie

$T_{1/2} = 5$ days $= \frac{\ln 2}{\lambda}$

$A = A_0 e^{-\lambda t}$

$5 \times 10^{-6} = 6.4 \times 10^{-4} e^{-\lambda t}$

$\frac{5}{6.4} \times 10^{-2} = e^{-\lambda t}$

$7.8 \times 10^{-3} = e^{-\lambda t}$

$\log(7.8 \times 10^{-3}) = -\lambda t \ln e$

$\ln(7.8 \times 10^{-3}) = -\frac{\lambda n2}{5} \cdot t$

$\therefore \frac{5 \times 4.853}{0.693} = t = 35$ days

Question93

The half life period of a radioactive substance is 60 days. The time taken for $\frac{7}{8}$ th of its original mass to disintegrate will be :
[28-Jul-2022-Shift-1]

Options:

A. 120 days

B. 130 days

C. 180 days

D. 20 days

Answer: C

Solution:

Solution:

$\because N = \frac{N_0}{2^{\frac{t}{T_{1/2}}}}$

$\Rightarrow 2^{\frac{t}{T_{1/2}}} = \frac{N_0}{N} = \frac{N_0}{\left(\frac{N_0}{8}\right)}$

$\Rightarrow 2^{\frac{t}{T_{1/2}}} = 8 = 2^3$

$\Rightarrow t = 3 \times T_{1/2} = 3 \times 60$

$= 180$ days

Question94

A freshly prepared radioactive source of half life 2 hours 30 minutes emits radiation which is 64 times the permissible safe level. The minimum time, after which it would be possible to work safely with source, will be _______ hours.
[28-Jul-2022-Shift-1]

Answer: 15

Solution:

Solution:

$A = A_0 \times 2^{-t/T}$

$\frac{A_0}{64} = A_0 \times 2^{-t/T}$

$\therefore\ t = 6T = 6 \times 2 \cdot 5 = 15$ hours

Question95

A radioactive sample decays $\frac{7}{8}$ times its original quantity in 15 minutes. The half-life of the sample is
[28-Jul-2022-Shift-2]

Options:

A. 5 min

B. 7.5 min

C. 15 min

D. 30 min

Answer: A

Solution:

$$N = \frac{N_0}{2^{\frac{t}{T_{1/2}}}}$$

$$\Rightarrow 2^{\frac{t}{T_{1/2}}} = \frac{N_0}{N} = \frac{N_0}{\left(\frac{N_0}{8}\right)} = 8$$

$$\Rightarrow \frac{t}{T_{1/2}} = 3$$

$$\Rightarrow T_{1/2} = \frac{15}{3} = 5\,\text{min}$$

Question96

Two radioactive materials A and B have decay constants 25λ and 16λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of B to that of A will be "e" after a time $\frac{1}{a\lambda}$. The value of a is _______.
[29-Jul-2022-Shift-2]

Answer: 9

Solution:

$$N_A = N_0 e^{-25\lambda t}$$

$$N_B = N_0 e^{-16\lambda t}$$

$$\frac{N_B}{N_A} = e = e^{9\lambda t}$$

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

Question97

The recoil speed of a hydrogen atom after it emits a photon in going from n = 5 state to n = 1 state will be
[26 Feb 2021 Shift 2]

Options:

A. 4.17m / s

B. 2.19m / s

C. 3.25m / s

D. 4.34m / s

Answer: A

Solution:

Solution:

As we know, mass of photon, $m = 1.6 \times 10^{-27} kg$ Using de-Broglie wavelength,

$\lambda = \frac{h}{p} = \frac{h}{mv}$ . . . (i)

where, h is Planck's constant $= 6.63 \times 10^{-34} J - s$ and p is momentum of photon.

By using Rydberg wavelength equation,

$$\frac{1}{\lambda} = R\left[\frac{1}{n_2^{\,2}} - \frac{1}{n_1^{\,2}}\right]$$

$$\frac{1}{\lambda} = 1.09 \times 10^7\left[\frac{1}{1^2} - \frac{1}{25}\right]$$

$$\Rightarrow \frac{1}{\lambda} = 1.09 \times 10^7\left[\frac{24}{25}\right]$$

$$\Rightarrow \lambda = \frac{25}{1.09 \times 10^7 \times 24}$$

Substituting values in Eq. (i), we get

$$v = \frac{h}{m\lambda} = \frac{6.63 \times 10^{-34} \times 1.09 \times 10^7 \times 24}{1.6 \times 10^{-27} \times 25}$$

$$= \frac{6.63 \times 1.09 \times 24}{1.6 \times 2.5} = 4.17 ms^{-1}$$

Question98

If λ_1 and λ_2 are the wavelengths of the third member of Lyman and first member of the Paschen series respectively, then the value of $\lambda_1 : \lambda_2$ is [26 Feb 2021 Shift 1]

Options:

A. 1 : 9

B. 7 : 108

C. 7 : 135

D. 1 : 3

Answer: C

Solution:

Solution:

By using Rydberg's formula, $\frac{1}{\lambda} = R\left[\frac{1}{n_2^{\,2}} - \frac{1}{n_1^{\,2}}\right]$

where, R is Rydberg constant.

For wavelength of third member of Lyman series $n_2 = 1$ and $n_1 = 4$.

$$\therefore \frac{1}{\lambda_1} = R\left[\frac{1}{1^2} - \frac{1}{4^2}\right] = R\left[\frac{1}{1} - \frac{1}{16}\right] \ . . . (i)$$

For wavelength of first member of Paschen series, $n_2 = 3$ and $n_1 = 4$

$\therefore \frac{1}{\lambda_2} = R\left[\frac{1}{3^2} - \frac{1}{4^2}\right] = R\left[\frac{1}{9} - \frac{1}{16}\right]$ . . . (ii)

On dividing Eq. (ii) by Eq. (i), we get

$$\frac{\lambda_1}{\lambda_2} = \frac{\left[\frac{1}{9} - \frac{1}{16}\right]}{\left[\frac{1}{1} - \frac{1}{16}\right]} = \frac{7}{9 \times 15} = \frac{7}{135}$$

Question99

The wavelength of the photon emitted by a hydrogen atom when an electron makes a transition from n = 2 to n = 1 state is [25 Feb 2021 Shift 2]

Options:

A. 121.8nm

B. 194.8nm

C. 490.7nm

D. 913.3nm

Answer: A

Solution:

Solution:

Given, electron is moving from $n = 2$ to $n = 1$.

From Bohr's hydrogen spectrum (Rydberg formula)

$$\frac{1}{\lambda} = R\left[\frac{1}{n_f^{\,2}} - \frac{1}{n_i^{\,2}}\right]$$

where, $\lambda =$ wavelength,

$R = 1.097 \times 10^7 m^{-1}$ (Rydberg's constant)

$\Rightarrow \frac{1}{\lambda} = 1.097 \times 10^7\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

$= 1.097 \times 10^7\left[\frac{1}{1} - \frac{1}{4}\right] = \frac{3}{4} \times 1.097 \times 10^7$

$\lambda = \frac{4}{3 \times 1.097 \times 10^7} = 1.215 \times 10^{-7}$

$= 121.5 \times 10^{-9} \sim eq121.8nm$

Question100

According to Bohr atom model, in which of the following transitions will the frequency be maximum ? [24 Feb 2021 Shift 2]

Options:

A. n = 4 to n = 3

B. n = 2 to n = 1

C. n = 5 to n = 4

D. n = 3 to n = 2

Answer: B

Solution:

Solution:
Let n_f, n_i be the final and initial orbit.
As we know that,
$\frac{1}{\lambda} = 109 \times 10^7 \left[\frac{1}{n_f^2} - \frac{1}{n_i^2} \right]$
Now, checking for each option, we get
(a) $\frac{1}{\lambda} \propto \left[\frac{1}{3^2} - \frac{1}{4^2} \right] = \left[\frac{1}{9} - \frac{1}{16} \right] = 0.05 \ldots$ (i)
(b) $\frac{1}{\lambda} \propto \left[\frac{1}{1} - \frac{1}{4} \right] = 0.75 \ldots$ (ii)
(c) $\frac{1}{\lambda} \propto \left[\frac{1}{16} - \frac{1}{25} \right] = 0.0225 \ldots$ (iii)
(d) $\frac{1}{\lambda} \propto \left[\frac{1}{4} - \frac{1}{9} \right] = 0.14 \ldots$ (iv)
The option (b) has highest value.
Since, frequency, $f = \frac{C}{\lambda} \Rightarrow f \propto \frac{1}{\lambda}$
∴ Frequency will be maximum for transition n = 2 to n = 1.

Question101

A radioactive sample is undergoing α-decay. At any time t_1, its activity is A and another time t_2, the activity is $\frac{A}{5}$. What is the average life time for the sample?
[26 Feb 2021 Shift 2]

Options:

A. $\frac{\ln 5}{t_2 - t_1}$

B. $\frac{t_1 - t_2}{\ln 5}$

C. $\frac{t_2 - t_1}{\ln 5}$

D. $\frac{\ln(t_2 + t_1)}{2}$

Answer: C

Solution:

Solution:
Given, activity pf radioactive element at time t_1,
$A_1 = A$
and at time t_2, $A_2 = A / 5$
As we know that,

activity at any time(A) = $A_0 e^{-\lambda t}$
where A_0 is activity at time t = 0.
$\therefore A = A_0 e^{-\lambda t_1}$ . . . (i)
and $A / 5 = A_0 e^{-\lambda t_2}$ . . . (ii)
$\Rightarrow 5 = e^{-\lambda t_1 + \lambda t_2}$
Taking log on both sides, we get
$\ln 5 = \lambda(t_2 - t_1) \ln e$
$\Rightarrow \ln 5 = \lambda(t_2 - t_1)$ [$\because \ln e = 1$]
$\Rightarrow \lambda = \ln 5 / (t_2 - t_1)$
$\Rightarrow$ Also, average life, $\tau = \frac{1}{\lambda}$
$\Rightarrow \tau = \frac{t_2 - t_1}{\ln 5}$

Question102

Two radioactive substances X and Y originally have N_1 and N_2 nuclei, respectively. Half-life of X is half of the half-life of Y. After three half-lives of Y, number of nuclei of both are equal. The ratio $\frac{N_1}{N_2}$ will be equal to
[25 Feb 2021 Shift 1]

Options:

A. $\frac{1}{8}$

B. $\frac{3}{1}$

C. $\frac{8}{1}$

D. $\frac{1}{3}$

Answer: C

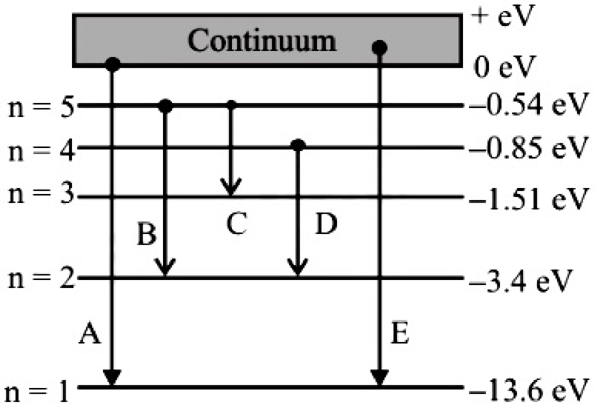
Solution:

Solution:
Given, initial amount of X and Y be N_1 and N_2.
Let half-life of X be t_x and y be t_y.
According to question, $t_x = \frac{t_y}{2} = t$
$\Rightarrow t_x = t$ and $t_y = 2t$
After 3 half-lives of Y,
$3t_y = 6t$
As we know that,
$N = N_0 e^{-\lambda t}$
where, N is the number of nuclei left undecayed.
and $t_{1/2} = \frac{0.693}{\lambda}$
$\lambda = \frac{0.693}{t_{1/2}}$
$\lambda_1 = \frac{0.693}{t}$ and $\lambda_2 = \frac{0.693}{2t}$
Since, after 3 half-lives of Y number of nuclei of both become equal.

$\therefore \therefore N_1 e^{-\lambda_1 6t} = N_2 e^{-\lambda_2 6t}$
$\Rightarrow N_1 / N_2 = e^{6t(-\lambda_2 + \lambda_1)}$
$\Rightarrow N_1 / N_2 = e^{6t\left(\frac{0.693}{t} - \frac{0.693}{2t}\right)}$
$= e^{0.693\left(\frac{6t}{t} - \frac{6t}{2t}\right)} = e^{0.693 \times 3} = 7.9 \sim eq8$
$\frac{N_1}{N_2} = \frac{8}{1}$

Question103

In the given figure, the energy levels of hydrogen atom have been shown along with some transitions marked A, B, C, D and E. The transitions A, B and C respectively represent :



[24feb2021shift1]

Options:

A. The ionization potential of hydrogen, second member of Balmer series and third member of Paschen series.

B. The first member of the Lyman series, third member of Balmer series and second member of Paschen series.

C. The series limit of Lyman series, third member of Balmer series and second member of Paschen series.

D. The series limit of Lyman series, second member of Balmer series and second member of Paschen series.

Answer: C

Solution:

Solution:
A corresponds to transition from $n = \infty$ to $n = 1$.
It is a series limit of Lymen series.
B corresponds to transition from $n = 5$ to $n = 2$.
It is a third member of Balmer series.
C corresponds to transition from $n = 5$ to $n = 3$, thus, it is second member of Paschen series.

Question104

Imagine that the electron in a hydrogen atom is replaced by a muon (μ). The mass of muon particle is 207 times that of an electron and charge is equal to the charge of an electron. The ionisation potential of this hydrogen atom will be
[18 Mar 2021 Shift 1]

Options:

A. 13.6eV

B. 2815.2eV

C. 331.2eV

D. 27.2eV

Answer: B

Solution:

Solution:
As we know that, the ionisation potential of the hydrogen,
$IP_H = 13.6eV$
We know that,
$IP = \frac{Z^2 mq^4}{8n^2h^2\varepsilon_0^2}$
$\Rightarrow IP \propto mq^4 \Rightarrow \frac{IP_\mu}{IP_H} = \frac{m_\mu q_\mu^4}{m_e q_e^4}$
$\Rightarrow \frac{IP}{IP_\mu} = \frac{m_\mu}{m_e}$ $[\because q_\mu = q_e]$
$IP_\mu = \frac{m_\mu}{m_e} \times IP_H = \frac{207 m_e}{m_e} \times 13.6$
$= 2815.2eV$

Question105

The atomic hydrogen emits a line spectrum consisting of various series. Which series of hydrogen atomic spectra is lying in the visible region?
[17 Mar 2021 Shift 2]

Options:

A. Brackett series

B. Paschen series

C. Lyman series

D. Balmer series

Answer: D

Solution:

Solution:

When an electron jumps from the higher energy level to $n = 2$ orbit, Balmer series of the line spectrum is obtained. The Balmer series of the hydrogen atom lies in the visible region. However, Brackett and Paschen series of hydrogen atom lies in the infrared region and Lyman series of hydrogen atom lies in the ultraviolet region.

Question106

A particle of mass m moves in a circular orbit in a central potential field $U(r) = U_0 r^4$. If Bohr's quantisation conditions are applied, radii of possible orbitals r_n vary with $n^{1/\alpha}$, where α is [17 Mar 2021 Shift 2]

Answer: 3

Solution:

Solution:
As we know, the force on the particle is given as
$F = -\frac{dU(r)}{dr}$
Given, $U(r) = U_0 r^4$
$\Rightarrow F = -\frac{d(U_0 r^4)}{dr} \Rightarrow F = -4U_0 r^3$
As we know, the force on the particle moving in a circular orbit of radius r will be centripetal force
$\left|\frac{mv^2}{r}\right| = 4U_0 r^3$
$\Rightarrow v^2 \propto r^4$
$v \propto r^2$ .....(i)
Hence, the velocity of the particle is square of the radius of the orbit. Using the Bohr's quantisation condition, which states that the electron revolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of $\frac{h}{2\pi}$, here, h is
Planck's constant.
i.e,
$n\frac{h}{2\pi} = mvr$ [From Eq. (i)]
$\Rightarrow r^3 \propto n \Rightarrow r \propto n^{1/3}$
Comparing the above relation with $n^{1/\alpha}$, we get
$\alpha = 3$

Question107

Which level of the single ionized carbon has the same energy as the ground state energy of hydrogen atom? [17 Mar 2021 Shift 1]

Options:

A. 1

B. 6

C. 4

D. 8

Answer: B

Solution:

Solution:
Since we know that, energy of hydrogen atom is

$E = -13.6 \frac{Z^2}{n^2}$

where, Z is the atomic number and n is the energy state.
∵ For hydrogen atom, $Z = 1$ and $n = 1$

$\Rightarrow E = \frac{-13.6(1)^2}{1^2}$

$\Rightarrow E = -13.6 eV$ ...(i)
For carbon atom, $Z = 6$, $n = ?$

$\Rightarrow E = \frac{-13.6(6)^2}{n^2}$....(ii)

According to question, carbon has same energy as the ground stat energy of hydrogen atom.
∴ From Eqs. (i) and (ii), we get

$-13.6 = \frac{-13.6(6)^2}{n^2} \Rightarrow n^2 = 6^2$

$\Rightarrow n = 6$

Question108

If an electron is moving in the nth orbit of the hydrogen atom, then its velocity v_n for the nth orbit is given as
[17 Mar 2021 Shift 1]

Options:

A. $v_n \propto n$

B. $v_n \propto \frac{1}{n}$ C.

C. $v_n \propto n^2$

D. $v_n \propto \frac{1}{n^2}$

Answer: B

Solution:

Solution:
As we know that, the velocity of electron in the nth shell of hydrogen atom is given by

$v_n = \frac{Z e^2}{2\varepsilon_0 nh}$

where, Z = atomic number,
n = order of orbit,
e = charge on an electron,
h = Planck's constant
and ε_0 = absolute permittivity of free space

$\Rightarrow v_n \propto \frac{1}{n}$

Question109

The first three spectral lines of H-atom in the Balmer series are given $\lambda_1, \lambda_2, \lambda_3$ considering the Bohr atomic model, the wavelengths of first and third spectral lines $\left(\frac{\lambda_1}{\lambda_3}\right)$ are related by a factor of approximately $x \times 10^{-1}$. The value of x to the nearest integer, is ....
[16 Mar 2021 Shift 1]

Answer: 15

Solution:

Since, we know that,

$$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1{}^2} - \frac{1}{n_2{}^2}\right) \text{......(i)}$$

where, $\lambda =$ wavelength of light emitted.
$R =$ Rydberg's constant,
$Z =$ atomic number,
$n_1 =$ principal quantum number of lower energy level
and $n_2 =$ principal quantum number of higher energy level.
Therefore, for 1st spectral line of Balmer series, $n_1 = 2$ and $n_2 = 3$

$$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\Rightarrow \frac{1}{\lambda_1} = Rz^2\left(\frac{5}{36}\right) \text{...(ii)}$$

Similarly, for 3rd spectral line, $n_1 = 2$ and $n_2 = 5$

$$\frac{1}{\lambda_3} = Rz^2\left(\frac{1}{2^2} - \frac{1}{5^2}\right)$$

$$\Rightarrow \frac{1}{\lambda_3} = Rz^2\left(\frac{21}{100}\right) \text{......(iii)}$$

Now, dividing Eq. (iii) by Eq. (ii), we get

$$\frac{\frac{1}{\lambda_3}}{\frac{1}{\lambda_1}} = \frac{Rz^2\left(\frac{21}{100}\right)}{Rz^2\left(\frac{5}{36}\right)} \Rightarrow \frac{\lambda_1}{\lambda_3} = \frac{21}{100} \times \frac{36}{5}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_3} = 1.512 = 15.12 \times 10^{-1}$$

Comparing with the given value in the question i.e., $x \times 10^{-1}$, the value of $x = 15$.

Question110

The decay of a proton to neutron is
[18 Mar 2021 Shift 2]

Options:

A. not possible as proton mass is less than the neutron mass

B. possible only inside the nucleus

C. not possible but neutron to proton conversion is possible

D. always possible as it is associated only with beta$^+$decay

Answer: B

Solution:

Solution:
The decay of a proton to neutron is possible only inside the nucleus because the mass of proton is less than the mass of neutron. This mass difference is compensated with the binding energy of nucleus. This decay is not possible outside the nucleus because particle cannot be decayed into the greater mass.

Question111

A radioactive sample disintegrates via two independent decay processes having half-lives $T_{1/2}^{(1)}$ and $T_{1/2}^{(2)}$, respectively. The effective half-life $T_{1/2}$ of the nuclei is [18 Mar 2021 Shift 1]

Options:

A. $T_{V2} = \frac{T_{1/2}^{(1)} + T_{1/2}^{(2)}}{T_{12}^{(1)} - T_{1/2}^{(2)}}$

B. $T_{1/2} = T_{1/2}^{(0)} + T_{1/2}^{(2)}$

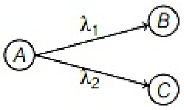
C. $T_{1/2} = \frac{T_{V2}^{(1)} T_{V2}^{(2)}}{T_{1/2}^{(1)} + T_{1/2}^{(2)}}$

D. None of these

Answer: C

Solution:

Solution:
The radioactive sample disintegrates via two independent decays as shown in the figure,



Here, λ is the net disintegrate constant.
λ_1 is the first decay constant,
and λ_2 is the second decay constant.
From the above figure,
$\lambda = \lambda_1 + \lambda_2$...(i)
As, we know that,
Half-life, $T_{1/2} = \frac{\ln(2)}{\lambda} \Rightarrow \lambda = \frac{\ln(2)}{T_{1/2}}$
Substituting in Eq. (i), we get
$\frac{\ln(2)}{T_{1/2}} = \frac{\ln(2)}{T_{1/2}^{(01)}} + \frac{\ln(2)}{T_{1/2}^{(2)}}$

$\Rightarrow T_{1/2} = \frac{T_{1/2}^{(1)} T_{1/2}^{(2)}}{T_{1/2}^{(1)} + T_{1/2}^{(2)}}$

Question112

Amplitude of a mass-spring system, which is executing simple harmonic motion decreases with time. If mass = 500g, decay constant = 20g/s, then how much time is required for the amplitude of the system to drop to half of its initial value? ($\ln 2 = 0.693$)
[16 Mar 2021 Shift 2]

Options:

A. 34.65s

B. 17.32s

C. 0.034s

D. 15.01s

Answer: A

Solution:

Solution:
Given,
Mass, $m = 500g$
Decay constant, $\lambda = 20g / s$
For damped oscillation,
$A = A_0 e^{-bbt / 2m}$....(i)
Here, b = damped constant = decay constant
As per question, the amplitude of the system is dropped to half of its initial value.
So, Eq. (i) becomes
$\frac{A_0}{2} = A_0 e^{-bt / 2m} \Rightarrow \frac{1}{2} = e^{-bt / 2m}$
$\Rightarrow 2 = e^{bt / 2m}$
$\Rightarrow 2 = e^{bt / 2m}$
Taking log on both sides of above equation, we get
$\log 2 = \log(e^{bt / 2m})$
$\Rightarrow \log 2 = \frac{bt}{2m} \Rightarrow t = \frac{2m}{b} \log 2$
$= \frac{2 \times 500 \times 0.693}{20}$
$[\because \log 2 = 0.693]$
$\Rightarrow t = 34.65s$

Question113

Calculate the time interval between 33% decay and 67% decay if half-life of a substance is 20min.
[16 Mar 2021 Shift 2]

Options:

A. 60min

B. 20min

C. 40min

D. 13min

Answer: B

Solution:

As we know that,
$N = N_0 e^{-\lambda t}$
where,
$N =$ number of radioactive atoms left undecayed,
$N_0 =$ original number of radioactive atoms,
$t =$ elapsed time
and $\lambda =$ decay constant.
$\Rightarrow N_1 = N_0 e^{-\lambda \cdot t_1}$....(i)
and $N_2 = N_0 e^{-\lambda t_2}$....(ii)
Consider Eq. (i), $N_1 = N_0 e^{-\lambda t_1}$
$\Rightarrow \frac{N_1}{N_0} = e^{-\lambda t_1} \Rightarrow 0.67 = e^{-\lambda t_1}$
$\Rightarrow \log(0.67) = \log\left(e^{-\lambda t_1}\right)$
$\Rightarrow \log 0.67 = -\lambda t_1$.....(iii)
Consider Eq. (ii), $N_2 = N_0 e^{-\lambda t_2}$
$\Rightarrow \frac{N_2}{N_0} = e^{-\lambda t_2} \Rightarrow 0.33 = e^{-\lambda t_2}$
$\Rightarrow \log(0.33) = \log\left(e^{-\lambda t_2}\right)$
$\Rightarrow \log(0.33) = -\lambda t_2$.....(iv)
Subtracting Eq. (iv) from Eq. (iii), we get
$\log 0.67 - \log 0.33 = -\lambda t_1 + \lambda t_2$
$\Rightarrow \log\left(\frac{0.67}{0.33}\right) = \lambda(t_2 - t_1) \Rightarrow \lambda(t_2 - t_1) = \log 2$
$\Rightarrow t_2 - t_1 = \frac{\log 2}{\lambda} = t_{1/2}$
$\therefore$ Half-life $= t_{1/2} = 20\text{min}$

Question114

The half-life of Au^{198} is 2.7 days. The activity of 1.50mg of Au^{198} if its atomic weight is $198 g mol^{-1}$ is ($N_A = 6 \times 10^{23}$ / mol) [16 Mar 2021 Shift 2]

Options:

A. 240Ci

B. 357Ci

C. 535Ci

D. 252Ci

Answer: B

Solution:

Given,
Half-life of Au^{198}, $T_{1/2} = 2.7$ days
Amount of Au^{198}, $m = 1.5mg = 1.5 \times 10^{-3}g$
Atomic weight of Au^{198}, $A = 198gmol^{-1}$
We know that activity, $A_0 = \lambda N_0$
where, $\lambda =$ decay constant $= \frac{\ln 2}{T_{1/2}}$
$N_0 =$ initial number of atoms $= \frac{m}{A}N_A$
$\Rightarrow = A_0\lambda \cdot \frac{m}{A}N_A = \frac{\ln 2}{T_{1/2}} \times \frac{1.5 \times 10^{-3}}{198} \times 6.023 \times 10^{23}$
$\Rightarrow A_0 = \frac{\ln 2 \times 1.5 \times 10^{-3} \times 6 \times 10^{23}}{2.7 \times 3600 \times 24 \times 198 \times 3.7 \times 10^{10}}Ci$
$[\because 1$ curie $(Ci) = 3.7 \times 10^{10}Bq]$
$\Rightarrow A_0 = 3.65 \times 10^2 Ci = 365Ci$
The answer is close to 357Ci.

Question115

The radiation corresponding to 3 → 2 transition of a hydrogen atom falls on a gold surface to generate photoelectrons. These electrons are passed through a magnetic field of $5 \times 10^{-4}T$. Assume that the radius of the largest circular path followed by these electrons is 7mm, the work function of the metal is: (Mass of electron $= 9.1 \times 10^{-31}kg$) [20 Jul 2021 Shift 1]

Options:

A. 1.36 eV

B. 1.88 eV

C. 0.16 eV

D. 0.82 eV

Answer: D

Solution:

1.51———n = 3
3.4———n = 3
13.6———n = 1
$3 \rightarrow 2 \Rightarrow 1.89eV$
$5 \times 10^{-4}T \quad r = 7mm$
$r = \frac{mv}{qB} \Rightarrow mv = qrB$
$\Rightarrow E = \frac{P^2}{2m} = \frac{(qRB)^2}{2m}$
$= \frac{(1.6 \times 10^{-19} \times 7 \times 10^{-3} \times 5 \times 10^{-4})^2}{2 \times 9.1 \times 10^{-31}} \text{Joule}$
$= \frac{3136 \times 10^{-52}}{18.2 \times 10^{-31} \times 1.6 \times 10^{-19}} \times eV$
$= 1.077eV$
We know work function = energy incident $(KE)_{electron}$
$\phi = 1.89 - 1.077 = 0.813eV$

Question116

The K_α X-ray of molybdenum has wavelength0.071nm. If the energy of a molybdenum atoms with a K electron knocked out is 27.5keV, the energy of this atom when an L electron is knocked out will be ______ keV. (Round off to the nearest integer)
[$h = 4.14 \times 10^{-15}$ eV s, $c = 3 \times 10^{8}$ ms^{-1}]
[27 Jul 2021 Shift 2]

Answer: 10

Solution:

Solution:

$E_{k_\alpha} = E_k - E_L$

$\frac{hc}{\lambda_{k_\alpha}} = E_k - E_L$

$E_L = E_k - \frac{hc}{\lambda_{k_\alpha}}$

$= 27.5\text{K eV} - \frac{12.42 \times 10^{-7}\text{eV m}}{0.071 \times 10^{-9}\text{m}}$

$E_L = (27.5 - 17.5)\text{keV}$

$= 10\text{keV}$

Question117

An electron and proton are separated by a large distance. The electron starts approaching the proton with energy 3 eV. The proton captures the electrons and forms a hydrogen atom in second excited state. The resulting photon is incident on a photosensitive metal of threshold wavelength 4000 Å. What is the maximum kinetic energy of the emitted photoelectron?
[27 Jul 2021 Shift 2]

Options:

A. 7.61 eV

B. 1.41 eV

C. 3.3 eV

D. No photoelectron would be emitted

Answer: B

Solution:

:

Initially, energy of electron $= +3\text{eV}$

finally, in 2^{nd} excited state,

energy of electron $= -\frac{(13.6\text{eV})}{3^2}$

$= -1.51\text{eV}$

Loss in energy is emitted as photon,

So, photon energy $\frac{hc}{\lambda} = 4.51\text{eV}$

Now, photoelectric effect equation

$KE_{max} = \frac{hc}{\lambda} - \phi = 4.51 - \left(\frac{hc}{\lambda_{th}}\right)$

$= 4.51\text{eV} - \frac{12400\text{eV}\,\text{Å}}{4000\text{Å}}$

$= 1.41\text{eV}$

Question118

Consider the following statements :
A. Atoms of each element emit characteristics spectrum.
B. According to Bohr's Postulate, an electron in a hydrogen atom, revolves in a certain stationary orbit.
C. The density of nuclear matter depends on the size of the nucleus.
D. A free neutron is stable but a free proton decay is possible.
E. Radioactivity is an indication of the instability of nuclei.
Choose the correct answer from the options given below :
[27 Jul 2021 Shift 2]

Options:

A. A, B, C, D and E

B. A, B and E only

C. B and D only

D. A, C and E only

Answer: B

Solution:

Solution:

(A) True, atom of each element emits characteristic spectrum.

(B) True, according to Bohr's postulates $mvr = \frac{nh}{2\pi}$ and hence electron resides into orbits of specific radius called stationary orbits.

(C) False, density of nucleus is constant

(D) False, A free neutron is unstable decays into proton and electron and antineutrino.

(E) True unstable nucleus show radioactivity.

Question119

A radioactive sample has an average life of 30 ms and is decaying. A capacitor of capacitance 200 μF is first charged and later connected

with resistor 'R'. If the ratio of charge on capacitor to the activity of radioactive sample is fixed with respect to time then the value of 'R' should be ______Ω.
[27 Jul 2021 Shift 1]

Answer: 150

Solution:

Solution:
$T_m = 30ms$
$C = 200\mu F$
$\frac{q}{N} = \frac{Q_0 e^{-t/RC}}{N_0 e^{-\lambda t}} = \frac{Q_0}{N_0} e^{t\left(\lambda - \frac{1}{RC}\right)}$
Since q / N is constant hence
$\lambda = \frac{1}{RC}$
$R = \frac{1}{\lambda C} = \frac{T_m}{C} = \frac{30 \times 10^{-3}}{200 \times 10^{-6}} = 150\Omega$

Question120

If ' f denotes the ratio of the number of nuclei decayed (N_d) to the number of nuclei at t = $0(N_0)$then for a collection of radioactive nuclei, the rate of change of f' with respect to time is given as :
[λ is the radioactive decay constant]
[27 Jul 2021 Shift 1]

Options:

A. $-\lambda(1 - e^{-\lambda t})$

B. $\lambda(1 - e^{-\lambda t})$

C. $\lambda e^{-\lambda t}$

D. $-\lambda e^{-\lambda t}$

Answer: C

Solution:

Solution:
$N = N_0 e^{-\lambda t}$
$N_d = N_0 - N$
$N_d = N_0(1 - e^{-\lambda t})$
$\frac{N_d}{N_0} = f = 1 - e^{-\lambda t}$
$\frac{df}{dt} = \lambda e^{-\lambda t}$

Question121

The nuclear activity of a radioactive element becomes $\left(\frac{1}{8}\right)^{th}$ of its initial value in 30 years. The half-life of radioactive element is _______ years. [25 Jul 2021 Shift 2]

Answer: 10

Solution:

Solution:

$A = A_0 e^{-\lambda t}$

$\frac{A_0}{8} = A_0 e^{-\lambda t} \Rightarrow \lambda t = \ln 8$

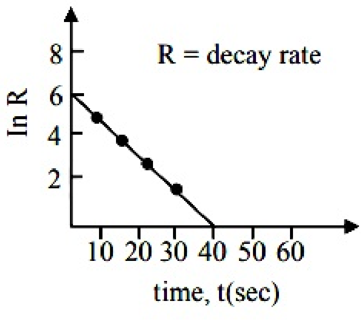
$\lambda t = 3 \ln 2$

$\frac{\ln 2}{\lambda} = \frac{t}{3} = \frac{30}{3} = 10$ years

----

Question122

For a certain radioactive process the graph between In R and t(sec) is obtained as shown in the figure.
Then the value of half life for the unknown radioactive material is approximately :



[20 Jul 2021 Shift 2]

Options:

A. 9.15 sec

B. 6.93 sec

C. 2.62 sec

D. 4.62 sec

Answer: D

Solution:

$R = R_0 e^{-\lambda t}$

$\ln R = \ln R_0 - \lambda t$

$-\lambda$ is slope of straight line

$\lambda = \frac{3}{20}$

$t_{1/2} = \frac{\ln 2}{\lambda} = 4.62$

Question123

A radioactive substance decays to $\left(\frac{1}{16}\right)^{th}$ of its initial activity in 80 days. The half life of the radioactive substance expressed in days is ______.
[20 Jul 2021 Shift 2]

Answer: 20

Solution:

$$N_0 \xrightarrow{t\frac{1}{2}} \frac{N_0}{2} \xrightarrow{t\frac{1}{2}} \frac{N_0}{4} \xrightarrow{t\frac{1}{2}} \frac{N_0}{8} \xrightarrow{t\frac{1}{2}} \frac{N_0}{16}$$

$4 \times t_{1/2} = 80$

$t_{1/2} = 20$ days

Question124

A radioactive material decays by simultaneous emissions of two particles with half lives of 1400 years and 700 years respectively. What will be the time after the which one third of the material remains ? (Take ln 3 = 1.1)
[20 Jul 2021 Shift 1]

Options:

A. 1110 years

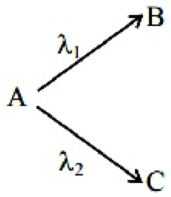
B. 700 years

C. 340 years

D. 740 years

Answer: D

Solution:



Given $\lambda_1 = \frac{\ln 2}{700}$/ year, $\lambda_2 = \frac{\ln 2}{1400}$/ year

$\therefore \lambda_{net} = \lambda_1 + \lambda_2 = \ln 2\left[\frac{1}{700} + \frac{1}{1400}\right]$

$= \frac{3\ln 2}{1400}$ / year

Now, Let initial no. of radioactive nuclei be No.

$\therefore \frac{N_0}{3} = N_0 e^{-\lambda_{net}}$

$\Rightarrow \ln\frac{1}{3} = -\lambda_{net} t$

$\Rightarrow 1.1 = \frac{3 \times 0.693}{1400} t \Rightarrow t \approx 740$ years

Hence option 4

Question125

From the given data, the amount of energy required to break the nucleus of aluminium ${}_{13}^{27}Al$ is _____ $x \times 10^{-3}$J
Mass of neutron = 1.00866u
Mass of proton = 1.00726u
Mass of Aluminium nucleus = 27.18846u
(Assume 1 u corresponds to x J of energy)
(Round off to the nearest integer)
[25 Jul 2021 Shift 2]

Answer: 27

Solution:

$\Delta m = (Z m_P + (A - Z)m_n) - M_{Al}$
$= (13 \times 1.00726 + 14 \times 1.00866) - 27.18846$
$= 27.21562 - 27.18846$
$= 0.02716u$
$E = 27.16x \times 10^{-3}J$

Question126

A nucleus with mass number 184 initially at rest emits an α-particle. If the Q value of the reaction is 5.5MeV, calculate the kinetic energy of the α− particle.
[22 Jul 2021 Shift 2]

Options:

A. 5.0 MeV

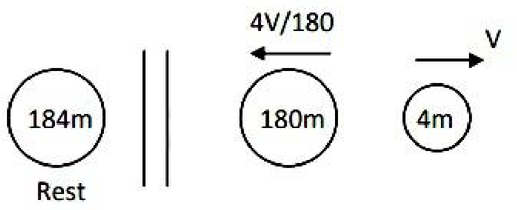
B. 5.5 MeV

C. 0.12 MeV

D. 5.38 MeV

Answer: D

Solution:



$$\frac{1}{2}(4m)v^2 + \frac{1}{2}(180m)\left(\frac{4v}{180}\right)^2 = 5.5M\,eV$$

$$\Rightarrow \frac{1}{2}4mv^2\left[1 + 45\left(\frac{4}{180}\right)^2\right] = 5.5M\,eV$$

$$\Rightarrow K.E_{\alpha} = \frac{5.5}{1 + 45.\left(\frac{4}{180}\right)^2}M\,eV$$

$$K.E_{\alpha} = 5.38M\,eV$$

Question127

A nucleus of mass M emits γ-ray photon of frequency 'v'. The loss of internal energy by the nucleus is :
[Take 'c' as the speed of electromagnetic wave]
[20 Jul 2021 Shift 1]

Options:

A. hv

B. 0

C. $hv\left[1 - \frac{hv}{2Mc^2}\right]$

D. $hv\left[1 + \frac{hv}{2Mc^2}\right]$

Answer: D

Solution:

Solution:
Energy of γ ray $[E_{\gamma}] = hv$
Momentum of γ ray

$[P_\gamma] = \frac{h}{\lambda} = \frac{hv}{C}$
Total momentum is conserved.
$\vec{P}_\gamma + \vec{P}_{Nu} = 0$
Where $\vec{P}_{Nu} =$ Momentum of decayed nuclei
$\Rightarrow P_\gamma = P_{Nu}$
$\Rightarrow \frac{hv}{C} = P_{Nu}$
⇒ K.E. of nuclei
$= \frac{1}{2} M v^2 = \frac{(P_{Nu})^2}{2M} = \frac{1}{2M}\left[\frac{hv}{C}\right]^2$
Loss in internal energy $= E_\gamma + K.E_{Nu}$
$= hv + \frac{1}{2M}\left[\frac{hv}{C}\right]^2$
$= hv\left[1 + \frac{hv}{2MC^2}\right]$

Question128

x different wavelengths may be observed in the spectrum from a hydrogen sample if the atoms are exited to states with principal quantum number n = 6 ? The value of x is .... [27 Aug 2021 Shift 2]

Answer: 15

Solution:

Solution:

Given, principal quantum number, $n = 6$ Number of wavelength, $N = \frac{n(n-1)}{2}$

$= \frac{6(6-1)}{2} = 3(5) = 15$
$x = 15$
$\therefore x = 15$

Question129

A free electron of 2.6 eV energy collides with a H^+ ion. This results in the formation of a hydrogen atom in the first excited state and a photon is released. Find the frequency of the emitted photon. $(h = 6.6 \times 10^{-34} Js)$ [31 Aug 2021 Shift 2]

Options:

A. 1.45×10^{16} MHz

B. 0.19×10^{15} MHz

C. 1.4510^{9} MHz

D. 9.0×10^{27} MHz

Answer: C

Solution:

Solution:
Given that, energy of free electron,
$E_1 = 2.6\,\text{eV}$
We know that, the energy of H-atom in its first excited state (n = 2),
$E_2 = \frac{-13.6}{2^2} = -\frac{13.6}{4}\,\text{eV}$
Now, the energy of emitted photons will be the difference ofthese two energies E_1 and E_2.
$\Delta E = E_1 - E_2$
$\therefore hv = \left[2.6 - \left(-\frac{13.6}{4}\right)\right]\text{eV}$
$\Rightarrow V = \frac{(10.4 + 13.6) \times 1.6 \times 10^{-19}}{4 \times 6.6 \times 10^{-34}} = 1.45 \times 10^{9}\,\text{MHz}$

Question130

A particular hydrogen like ion emits radiation of frequency 2.92×10^{15} Hz when it makes transition from n = 3 to n = 1. The frequency in Hz of radiation emitted in transition from n = 2 to n = 1 will be [26 Aug 2021 Shift 1]

Options:

A. 0.44×10^{15}

B. 6.57×10^{15}

C. 4.38×10^{15}

D. 246×10^{15}

Answer: D

Solution:

Solution:
The frequency of the emitted radiation by a particular hydrogen like ion when it makes transition from $n_1 = n_{initial}$ to $n_2 = n_{final}$ is given by
$f = RZ^2C\left(\frac{1}{n_2} - \frac{1}{n_1}\right)$
where, c = velocity of light
and R = Rydberg's constant.
For H-atom, Z = 1
So, for transition from n = 3 to n = 1
$f_1 = R_C\left(1 - \frac{1}{3^2}\right)$ ...(i)
Similarly for transition from n = 2 to n = 1,

$f_2 = R_C\left(1 - \frac{1}{2^2}\right)$ ...(ii)

Dividing Eq. (i) by Eq. (ii), we get

$$\frac{f_1}{f_2} = \frac{Rc\left(1 - \frac{1}{9}\right)}{Rc\left(1 - \frac{1}{4}\right)} = \frac{\frac{8}{9}}{34} = \frac{32}{27}$$

Here, $f_1 = 2.92 \times 10^{15}\,\text{Hz}$

$$\Rightarrow \frac{2.92 \times 10^{15}}{f_2} = \frac{32}{27}$$

$$\Rightarrow f_2 = \frac{2.92 \times 10^{15} \times 27}{32}$$

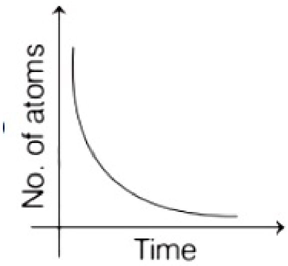
$$= 2.46 \times 10^{15}\,\text{Hz}$$

Question131

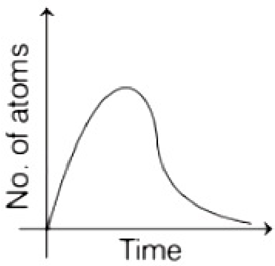
A sample of a radioactive nucleus A disintegrates to another radioactive nucleus B, which in turn disintegrates to some other stable nucleus C. Plot of a graph showing the variation of number of atoms of nucleus B versus time is
(Assume that at t = 0, there are no B atoms in the sample)
[31 Aug 2021 Shift 1]

Options:

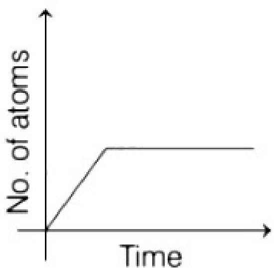
A.



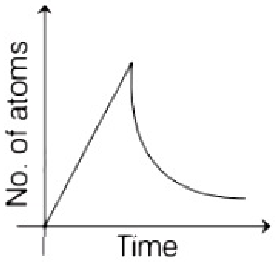
B.



C.



D.



Answer: B

Solution:

Solution:
According to given question, the decay is as shown below
$A \underset{\lambda A}{\rightarrow} B \underset{\lambda B}{\rightarrow} C(\text{Stable})$
Let N_0 be the original number of atoms in the radioactive nucleus A.
Initially at t = 0,
Number of atoms of B in the sample is zero.
According to radioactive decay law,
i.e. $N = N_0 e^{-\lambda t}$ ...(i)
With the increase in time t , the number of atoms of B will start increasing and reaches a maximum value.
After reaching the maximum value, B will start decaying into C.
Since, number of atoms varies with time following an exponential law i.e. Eq. (i).
So, the graph between number of atoms and t will be exponential in nature. Thus, the correct option is (b).

Question132

There are 10^{10} radioactive nuclei in a given radioactive element. Its half-life time is 1 min. How many nuclei will remain after 30 s? $(\sqrt{2} = 1.414)$ [27 Aug 2021 Shift 1]

Options:

A. 2×10^{10}

B. 7×10^{9}

C. 10^{5}

D. 4×10^{10}

Answer: B

Solution:

Solution:
Initial number of radioactive nuclei, $N_0 = 10^{10}$
Half-life, $t_{\frac{1}{2}} = 1 \text{ min} = 60\text{s}$
Time, t = 30s
We know that, number of nuclei remaining in radioactive decay after time t is given by
$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$
Substituting the values in above relation, we get

$\frac{N}{10^{10}} = \left(\frac{1}{2}\right)^{\frac{30}{60}} = \left(\frac{1}{2}\right)^{\frac{1}{2}} = \frac{1}{\sqrt{2}}$

$\Rightarrow N = \frac{1}{\sqrt{2}} \times 10^{10} = 0.707 \times 10^{10}$

$\Rightarrow N \approx 7 \times 10^{9}$

Thus, the radioactive nuclei remaining after 30s is 7×10^{9}.

Question133

At time t = 0, a material is composed of two radioactive atoms A and B , where $N_A(0) = 2N_B(0)$. The decay constant of both kind of radioactive atoms is λ. However, A disintegrates to B and B disintegrates to C. Which of the following figures represents the evolution of $\frac{N_B(t)}{N_B(0)}$ with respect to time t ?

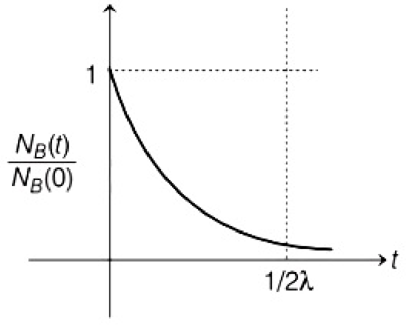
[$N_A(0)$ = Number of A atoms at t = 0]

[$N_B(0)$ = Number of B atoms at t = 0]

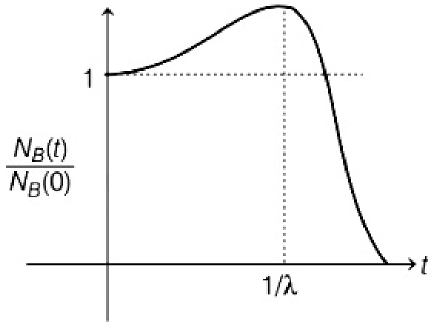
[26 Aug 2021 Shift 2]

Options:

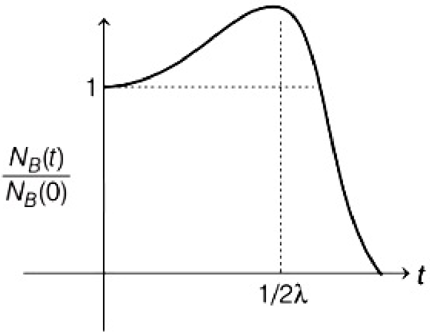
A.



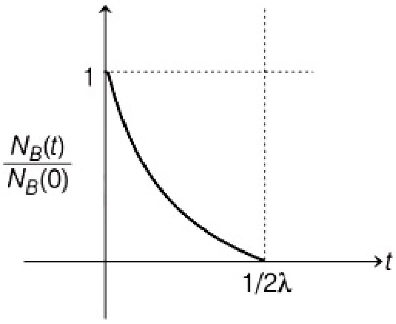
B.



C.



D.



Answer: C

Solution:

Solution:
Given, at time t = 0, $N_A(0) = 2N_B(0)$
Decay constant is same for both radioactive atoms as λ.
For A → B ,
$\frac{d\,N_B(t)}{d\,t} = \lambda N_A(t) - \lambda N_B(t)$
Substituting $N_A(0)e^{-\lambda t}$ for $N_A(t)$ in above expression, we get
$\frac{d\,N_B(t)}{d\,t} = \lambda N_A(0)e^{-\lambda t} - \lambda N_B(t)$
$= 2\lambda N_B(0)e^{-\lambda t} - \lambda N_B(t)$
$\Rightarrow \frac{d\,N_B(t)}{d\,t} + \lambda N_B(t) = 2\lambda N_B(0)e^{-\lambda t}$
Multiplying both sides by $e^{\lambda t}$, we get
$e^{\lambda t}\left[\frac{d\,N_B(t)}{d\,t} + \lambda N_B(t)\right] = 2\lambda N_B(0)e^{-\lambda t} \times e^{\lambda t}$
$\Rightarrow \frac{d}{d\,t}[N_B(t)e^{\lambda t}] = 2\lambda N_B(0)$
Integrating both sides,
$[N_B(t)e^{\lambda t}] = 2\lambda N_B(0)t + C$ ...(i)
Putting t = 0 in above expression,
$[N_B(0)e^{\lambda \times 0}] = 2\lambda N_B(0) \times 0 + C$
$\Rightarrow C = N_B(0)$
Putting value of C in Eq. (i)
$[N_B(t)e^{\lambda t}] = 2\lambda N_B(0)t + N_B(0)$ ...(ii)
$\Rightarrow N_B(t) = N_B(0)[1 + 2\lambda t]e^{-\lambda t}$
$\Rightarrow \frac{N_B(t)}{N_B(0)} = [1 + 2\lambda t]e^{-\lambda t}$
As, $N_B(t) = N_B(0)[1 + 2\lambda t)e^{-\lambda t}$
$\Rightarrow N_B(t) = C[1 + 2\lambda t]e^{-\lambda t}$ ...(iii)
The maximum value of $N_B(t)$ is obtained at
$\frac{d\,N_B(t)}{d\,t} = 0$
From Eq. (ii),

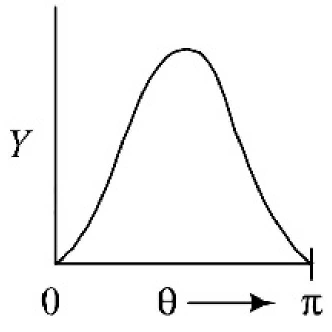
$\frac{d N_B(t)}{d t} = -\lambda C[1 + 2\lambda t]e^{-\lambda t} + 2C\lambda e^{-\lambda t} = 0$
Solving the above expression,
$t = \frac{1}{2\lambda} s$
Thus, maximum value of function will be at $t = \frac{1}{2\lambda} s$.
Hence, graph (c) is correct option.

Question134

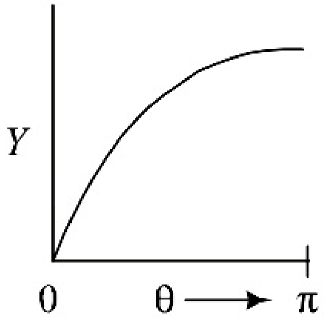
The graph which depicts the results of Rutherford gold foil experiment with
α-particles is:
θ : Scattering angle
α : Number of scattered a-particles detected
(Plots are schematic and not to scale)
[8 Jan. 2020 I]

Options:

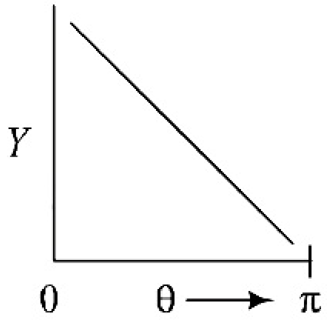
A.



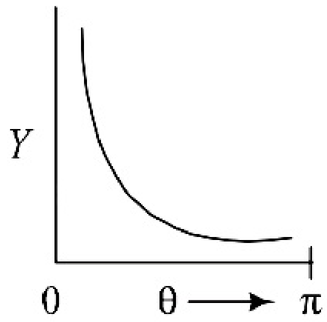
B.



C.



D.



Answer: C

Solution:

Solution:

Question135

The energy required to ionise a hydrogen like ion in its ground state is 9 Rydbergs. What is the wavelength of the radiation emitted when the electron in this ion jumps from the second excited state to the ground state?
[9 Jan. 2020 II]

Options:

A. 24.2 nm

B. 11.4 nm

C. 35.8 nm

D. 8.6 nm

Answer: B

Solution:

Solution:
According to Bohr's Theory the wavelength of the radiation emitted from hydrogen atom is given by

$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1{}^2} - \frac{1}{n_2{}^2}\right]$

$\because Z = 3$

$\therefore \frac{1}{\lambda} = 9R\left(1 - \frac{1}{9}\right)$

$\Rightarrow \lambda = \frac{1}{8R} = \frac{1}{8 \times 10973731.6}$ (R = 10973731.6m − 1)

$\Rightarrow \lambda = 11.39nm$

Question136

The first member of the Balmer series of hydrogen atom has a wavelength of 6561 Å. The wavelength of the second member of the Balmer series (in nm) is ______.
[NA 8 Jan. 2020 II]

Answer: 486

Solution:

Solution:
The wavelength of the spectral line of hydrogen spectrum is given by formula

$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$

Where, R = Rydberg constant
For the first member of Balmer series nF = 2, ni = 3

$\therefore \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$ ...(i)

For last member of Balmer series, nf = 2, ni = 4

So, $\frac{1}{\lambda'} = R\left[\frac{1}{4} - \frac{1}{16}\right]$ ...(ii)

Dividing (i) by (ii), we get

$\Rightarrow \frac{\lambda'}{\lambda} = \frac{5 \times 16}{9 \times 4 \times 3}$

$\Rightarrow \lambda' = \frac{5 \times 4 \times 656.1}{9 \times 3}(\text{nm}) = 486\text{nm}$

Question137

The time period of revolution of electron in its ground state orbit in a hydrogen atom is 1.6×10^{-16}s. The frequency of revolution of the electron in its first excited state (in s^{-1}) is:
[7 Jan. 2020 I]

Options:

A. 1.6×10^{14}

B. 7.8×10^{14}

C. 6.2×10^{15}

D. 5.6×10^{12}

Answer: B

Solution:

Solution:
For first excited state $n' = 3$

Time period $T \propto \frac{n^3}{z^2}$

$\Rightarrow \frac{T_2}{T_1} = \frac{n'^3}{n^3}$
$\therefore T2 = 8T1 = 8 \times 1.6 \times 10 - 16s$
$\therefore$ Frequency, $v = \frac{1}{T_2} = \frac{1}{8 \times 1.6 \times 10^{-16}}$
$\approx 7.8 \times 10^{14} Hz$

Question138

The activity of a radioactive sample falls from 700 s^{-1} to 500 s^{-1} in 30 minutes. Its half life is close to:
[7 Jan. 2020, II]

Options:

A. 72 min

B. 62 min

C. 66 min

D. 52 min

Answer: B

Solution:

Solution:
We know that
Activity, $A = A_0 e^{-\lambda t}$
$A = A_0 e^{-t \ln 2 / T_{1/2}} \left(\because \lambda = \frac{\ln_2}{T_{1/2}} \right)$
$\Rightarrow 500 = 700 e^{-t \ln 2 / T_{1/2}}$
$\Rightarrow \ln \frac{7}{5} = \frac{30 \ln 2}{T_{1/2}}$ ($\because$t = 30 minute)
$\Rightarrow T_{1/2} = 30 \frac{\ln 2}{\ln 1.4}$ = 61.8 minute
($\because \ln 2$ = 0.693 and $\ln .1 .4$ = 0.336)
$\Rightarrow T_{1/2} \approx$ 62 minute

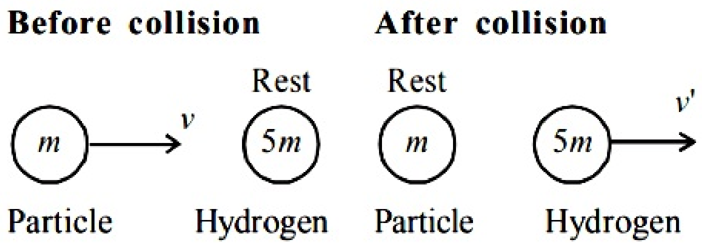
Question139

A particle of mass 200M eV / c^2 collides with a hydrogen atom at rest. Soon after the collision the particle comes to rest, and the atom recoils and goes to its first excited state. The initial kinetic energy of the particle (in eV) is $\frac{N}{4}$. The value of N is :

(Given the mass of the hydrogen atom to be 1 GeV/c^2)
[NA Sep. 05, 2020 (I)]

Answer: 51

Solution:



From linear momentum conservation, $L_i = L_f$

$mV + 0 = 0 + 5mV' \Rightarrow V' = \frac{v}{5}$

Loss of $KE = KE_i - KE_f = \frac{1}{2}mv^2 - \frac{1}{2}(5m)\left(\frac{v}{5}\right)^2$

$= \frac{1}{2}mv^2\left(1 - \frac{1}{5}\right) = \frac{4}{5}\left(\frac{mv^2}{2}\right)$

$= \frac{4}{5}KE_i = 10.2eV$

[$\because$ Energy in first excited state of atom $= 10.2eV$]

$KE_i = 12.75eV = \frac{N}{4} \Rightarrow N = 51$

The value of $N = 51$

Question140

In the line spectra of hydrogen atom, difference between the largest and the shortest wavelengths of the Lyman series is 304 Å. The corresponding difference for the Paschan series in Å is : _______.
[NA Sep. 04, 2020 (I)]

Answer: 10553.14

Solution:

From Bohr's formula for hydrogen atom,

$\frac{1}{\lambda} = R\left(\frac{1}{n_1^{\ 2}} - \frac{1}{n_2^{\ 2}}\right)$

$R = 1.097 \times 10^7 m^{-1}$

$\frac{1}{\lambda_{min}} = R(1) = R \because n_2 = \infty$ and $n_1 = 1$

$1\lambda_{max} = R\left\{1 - \frac{1}{4}\right\} = \frac{3R}{4} \because n_1 = 2, n_1 = 1$

$\therefore \lambda_{max} - \lambda_{min.} = \frac{4}{3R} - \frac{1}{R} = \frac{1}{3R} = 304($ Given $)$

For Paschen series :

$\lambda'_{min.} = R\left(\frac{1}{9}\right)$ and $\lambda'_{max.} = R\left(\frac{1}{9} - \frac{1}{16}\right) = \frac{7R}{16 \times 9}$

$\lambda'_{max.} - \lambda'_{min.} = \frac{16 \times 9}{7R} - \frac{9}{R} = \frac{81}{7R}$

or, $\lambda'_{max.} - \lambda'_{min.} = \frac{81}{7R} = \frac{81 \times 3}{7 \times 3R} = \frac{81 \times 3}{7} \times 304 \left(\because \frac{1}{3R} = 304Å\right)$

∴ For Pachen series, $\lambda'_{max} - \lambda_{min}' = 10553.14$

Question141

In a hydrogen atom the electron makes a transition from $(n+1)^{th}$ level to the n^{th} level. If $n >> 1$, the frequency of radiation emitted is proportional to :
[Sep. 02, 2020 (II)]

Options:

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

B. $\frac{1}{n^3}$

C. $\frac{1}{n^2}$

D. $\frac{1}{n^4}$

Answer: B

Solution:

Solution:

Total energy of electron in n^{th} orbit of hydrogen atom

$E_n = -\frac{Rhc}{n^2}$

Total energy of electron in $(n+1)^{th}$ level of hydrogen atom

$E_{n+1} = -\frac{Rhc}{(n+1)^2}$

When electron makes a transition from $(n+1)^{th}$ level to n^{th} level

Change in energy,

$\Delta E = E_{n+1} - E_n$

$hv = Rhc . \left[\frac{1}{n^2} - \frac{1}{(n+1)^2}\right] (\because E = hv)$

$v = R . c\left[\frac{(n+1)^2 - n^2}{n^2(n+1)^2}\right]$

$v = R . c\left[\frac{1+2n}{n^2(n+1)^2}\right]$

For $n >> 1$

$\Rightarrow v = R . c\left[\frac{2n}{n^2 \times n^2}\right] = \frac{2RC}{n^3}$

$\Rightarrow v \propto \frac{1}{n^3}$

Question142

The radius R of a nucleus of mass number A can be estimated by the formula $R = (1.3 \times 10^{-15})A^{1/3}$m. It follows that the mass density of a nucleus is of the order of :
($M_{prot.} \cong M_{neut.} \simeq 1.67 \times 10^{-27}$kg)
[Sep. 03, 2020 (II)]

Options:

A. 10^{3}kgm^{-3}

B. 10^{10}kgm^{-3}

C. 10^{24}kgm^{-3}

D. 10^{17}kgm^{-3}

Answer: D

Solution:

Density of nucleus, $\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{mA}{\frac{4}{3}\pi R^3}$

$\Rightarrow \rho = \frac{mA}{\frac{4}{3}\pi (R_0 A^{1/3})^3} (\because R = R_0 A^{1/3})$

Here m = mass of a nucleon

$\therefore \rho = \frac{3 \times 1.67 \times 10^{-27}}{4 \times 3.14 \times (1.3 \times 10^{-15})^3}$ (Given, $R_0 = 1.3 \times 10^{-15}$)

$\Rightarrow \rho = 2.38 \times 10^{17} \text{kg/m}^3$

Question143

You are given that mass of ${}_3^7\text{Li} = 7.0160$u
Mass of ${}_2^4\text{He} = 4.0026$u
and Mass of ${}_1^1\text{H} = 1.0079$u
When 20g of ${}_3^7\text{Li}$ is converted into ${}_2^4\text{He}$ by proton capture, the energy liberated, (in kWh), is :
[Mass of nucleon left. = 1GeV / c^2]
[Sep. 06,2020 (I)]

Options:

A. 4.5×10^{5}

B. 8×10^{6}

C. 6.82×10^{5}

D. 1.33×10^{6}

Answer: D

Solution:

$_3^7Li + _1^1H \rightarrow 2(_2^4He)$
$\Delta m \rightarrow [m_{Li} + m_H] - 2[M_{He}]$
Energy released $= \Delta mc^2$
In use of 1g Li energy released $= \frac{\Delta mc^2}{m_{Li}}$
In use of 20g energy released $= \frac{\Delta mc^2}{m_{Li}} \times 20g$
$= \frac{[(7.016 + 1.0079) - 2 \times 4.0026]u \times c^2}{7.016 \times 1.6 \times 10^{-24}} \times 20g$
$= \left(\frac{0.0187 \times 1.6 \times 10^{-19} \times 10^9}{7.016 \times 1.6 \times 10^{-24}} \times 20\right) = 480 \times 10^{10} J$
$\because 1J = 2.778 \times 10^{-7} kWh$
$\therefore$ Energy released $= 480 \times 10^{10} \times 2.778 \times 10^{-7}$
$= 1.33 \times 10^6 kWh$

Question144

Given the masses of various atomic particles $m_p = 1.0072u$ $m_n = 1.0087u$, $m_e = 0.000548u$, $m_{\bar{v}} = 0$, $m_d = 2.0141u$, wherep equiv proton, n≡ neutron, e≡ electron, $\bar{v}$≡ antineutrino and d ≡ deuteron. Which of the following process is allowed by momentum and energy conservation?
[Sep. 06,2020 (II)]

Options:

A. n + n→ deuterium atom (electron bound to the nucleus)

B. $p \rightarrow n + e^+ + \bar{v}$

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

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

Answer: C

Solution:

Solution:
For the momentum and energy conservation, mass defect (Δm) should be positive. Since some energy is lost in every process.
$(m_p + m_n) > m_d$

Question145

Find the Binding energy per neucleon for $_{50}^{120}Sn$. Mass of proton $m_p = 1.00783U$, mass of neutron $m_n = 1.00867U$ and mass of tin nucleus

$m_{Sn} = 119.902199U$.
(take $1\,U = 931 MeV$)
[Sep. 04,2020 (II)]

Options:

A. 7.5 MeV

B. 9.0 MeV

C. 8.0 MeV

D. 8.5 MeV

Answer: D

Solution:

Solution:
Mass defect,
$\Delta m = (50m_p + 70m_n) - (m_{sn})$
$= (50 \times 1.00783 + 70 \times 1.008) - (119.902199)$
$= 1.096$
Binding energy $= (\Delta m)C^2 = (\Delta m) \times 931 = 1020.56$
$\frac{\text{Binding energy}}{\text{Nucleon}} = \frac{1020.5631}{120} = 8.5 MeV$

Question146

In a reactor, 2kg of $_{92}U^{235}$ fuel is fully used up in 30 days. The energy released per fission is 200MeV. Given that the Avogadro number, $N = 6.023 \times 10^{26}$ per kilo mole and $1eV = 1.6 \times 10^{-19}J$. The power output of the reactor is close to:
[Sep. 02, 2020 (I)]

Options:

A. 35 MW

B. 60 MW

C. 125 MW

D. 54 MW

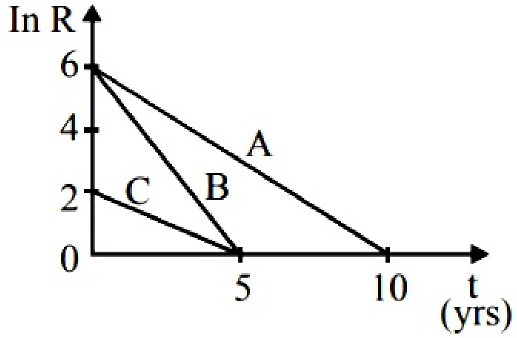
Answer: B

Solution:

Solution:
Power output of the reactor,
$P = \frac{\text{energy}}{\text{time}}$
$= \frac{2}{235} \times \frac{6.023 \times 10^{26} \times 200 \times 1.6 \times 10^{-19}}{30 \times 24 \times 60 \times 60} \simeq 60 MW$

Question147

Activities of three radioactive substances A, B and C are represented by the curves A, B and C, in the figure. Then their half-lives $T_{\frac{1}{2}}(A) : T_{\frac{1}{2}}(B) : T_{\frac{1}{2}}(C)$ are in the ratio:



[Sep. 05, 2020 (I)]

Options:

A. 2 : 1 : 1

B. 3 : 2 : 1

C. 2 : 1 : 3

D. 4 : 3 : 1

Answer: C

Solution:

Solution:

Since, $R = R_0 e^{-\lambda t}$

$\ln R = \ln R_0 + (-\lambda \ln t)$

$\lambda = \frac{\ln 2}{t_{1/2}} =$ Slope

$\lambda_A = \frac{6}{10} \Rightarrow T_A = \frac{10}{6} \ln 2$

$\lambda_B = \frac{6}{5} \Rightarrow T_B = \frac{5 \ln 2}{6}$

$\lambda_C = \frac{2}{5} \Rightarrow T_C = \frac{5 \ln 2}{6}$

$\therefore T_{\frac{1}{2}A} : T_{\frac{1}{2}B} : T_{\frac{1}{2}C} = \frac{10}{6} : \frac{5}{6} : \frac{15}{6} = 2 : 1 : 3$

Question148

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

[Sep. 05, 2020 (II)]

Options:

A. 9 sec.

B. 6 sec.

C. 55 sec.

D. 12 sec.

Answer: A

Solution:

Let λ_1 and λ_2 be the decay constants of two process.
N be the number of nuclei left undecayed after two process.
From the law of radioactive decay we have $-\frac{dN}{dt} = \lambda_1 N + \lambda_2 N \left[\because -\frac{dN}{dt} = \lambda N \right]$
$\Rightarrow -\frac{dN}{dt} = (\lambda_1 + \lambda_2)N$
$\Rightarrow \lambda_{eq.} = (\lambda_1 + \lambda_2)$
$\Rightarrow \frac{\ln 2}{T} = \frac{\ln 2}{T_1} + \frac{\ln 2}{T_2} \left(\because \lambda = \frac{\ln 2}{T} \right)$
$\Rightarrow \frac{1}{T} = \frac{1}{T_1} + \frac{1}{T_2}$
$\Rightarrow \frac{1}{T} = \frac{1}{10} + \frac{1}{100} = \frac{11}{100}$ [Given: $T_1 = 10s$ & $T_2 = 100s$]
$\Rightarrow T = \frac{100}{11} = 9\,\text{sec}$

Question149

In a radioactive material, fraction of active material remaining after time t is 9 / 16. The fraction that was remaining after t / 2 is : [Sep. 03, 2020 (I)]

Options:

A. $\frac{4}{5}$

B. $\frac{3}{5}$

C. $\frac{3}{4}$

D. $\frac{7}{8}$

Answer: C

Solution:

Solution:
As we know, for first order decay, $N(t) = N_0 e^{-\lambda t}$
According to question,
$\frac{N(t)}{N_0} = \frac{9}{16} = e^{-\lambda t}$
After time, t / 2

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

$\frac{N(t/2)}{N_0} = \sqrt{e^{-\lambda t}} = \sqrt{\frac{9}{16}}$

$\therefore N(t/2) = \frac{3}{4} N_0$

Question150

In a hydrogen like atom, when an electron jumps from the M-shell to the L-shell, the wavelength of emitted radiation is l. If an electron jumps from N-shell to the L-shell, the wavelength of emitted radiation will be:
[11 Jan 2019 II]

Options:

A. $\frac{27}{20}\lambda$

B. $\frac{16}{25}\lambda$

C. $\frac{25}{16}\lambda$

D. $\frac{20}{27}\lambda$

Answer: D

Solution:

Solution:
When electron jumps from M → L shell

$\frac{1}{\lambda} = K\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{K \times 5}{36}$ ..... (i)

When eletron jumps from N → L shell

$\frac{1}{\lambda'} = K\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{K \times 3}{16}$ ....(ii)

solving equation (i) and (ii) we get

$\lambda' = \frac{20}{27}\lambda$

Question151

Consider the nuclear fission
$Ne^{20} \rightarrow He^4 + C^{12}$
Given that the binding energy/nucleon of Ne^{20}, He^4 and C^{12} are, respectively, 8.03MeV, 7.07MeV and 7.86MeV identify the correct statement:
[10 Jan. 2019 II]

Options:

A. energy of 12.4 MeV will be supplied

B. 8.3 MeV energy will be released

C. energy of 3.6 MeV will be released

D. energy of 11.9 MeV has to be supplied

Answer: D

Solution:

Solution:

Question152

In a radioactive decay chain, the initial nucleus is $_{90}^{232}Th$.At the end there are 6α -particles and 4β -particles which are emitted. If the end nucleus is $_{Z}^{A}X$, A and Z are given by :
[12 Jan. 2019, II]

Options:

A. A = 208 ; Z = 80

B. A = 202 ; Z = 80

C. A = 208 ; Z = 82

D. A = 200; Z = 81

Answer: C

Solution:

Solution:
When one α - particle emitted then danghter nuclei has 4 unit less mass number (A) and 2 unit less atomic (z) number (z).
$_{90}^{232}Th \rightarrow _{78}^{208}Y + 6_{2}^{4}He$
$_{78}^{208}Y \rightarrow _{82}^{208}X + 4\beta$ praticle

Question153

Using a nuclear counter the count rate of emitted particles from a radioactive source is measured. At t =0 it was 1600 counts per second and t = 8 seconds it was 100 counts per second. The count rate observed,as counts per second, at t = 6 seconds is close to:
[10 Jan. 2019 I]

Options:

A. 200

B. 150

C. 400

D. 360

Answer: A

Solution:

Solution:
According to question, at t = 0, A0 = $\frac{dN}{dt}$ = 1600C / s
and at t = 8s, A = 100C / s
$\therefore \frac{A}{A_0} = \frac{1}{16}$ in 8s
Therefore half life period, $t_{1/2}$ = 2s
$\therefore$ Activity at t = 6s = $1600\left(\frac{1}{2}\right)^3$ = 200C / s

----

Question154

A sample of radioactive material A, that has an activity of 10 mCi (1Ci = 3.7×10^{10} decays/s), has twice the number of nuclei as another sample of a different radioactive material B which has an acitvity of 20 mCi. The correct choices for halflives of A and B would then be respectively:
[9 Jan. 2019 I]

Options:

A. 5 days and 10 days

B. 10 days and 40 days

C. 20 days and 5 days

D. 20 days and 10 days

Answer: C

Solution:

Solution:
Activity A = 1 N
For material, A → 10 = (2 N0)1A
For material, B → 20 = N01B
$\Rightarrow \lambda_B = 4\lambda_A \therefore T_{1/A} = 4T_{1/2B} \left[\because T_{1/2} = \frac{0.693}{\lambda}\right]$
i.e. 20 days half-lives for A and 5 days $(T_{1/2})_B$ For material B.

Question155

At a given instant, say t = 0, two radioactive substances A and B have

equal activities. The ratio $\frac{R_B}{R_A}$ of their activities after time t itself decays with time t as e^{-3t}. If the half-life of A is $\ln 2$, the half-life of B is:
[9 Jan. 2019 II]

Options:

A. $4 \ln 2$

B. $\frac{\ln 2}{2}$

C. $\frac{\ln 2}{4}$

D. $2 \ln 2$

Answer: C

Solution:

Halflife of A = ln2

$\left(t_{\frac{1}{2}}\right)A = \frac{\ln 2}{\lambda}$

$\therefore \lambda_A = 1$

at $t = 0 R_A = R_B$

$N_A e^{-\lambda AT} = N_B e^{-\lambda BT}$

$N_A = N_B$ at $t = 0$

At $t = t \frac{R_B}{R_A} = \frac{N_0 e^{-\lambda_B t}}{N_0 e^{-\lambda_A t}}$

$e^{-(\lambda_B - \lambda_A)t} = e^{-3t}$

$\Rightarrow \lambda_B - \lambda_A = 3$

$\lambda_B = 3 + \lambda_A = 4$

$(t_{1/2})_B = \frac{\ln 2}{\lambda_B} = \frac{\ln 2}{4}$

Question156

An excited He^+ ion emits two photons in succession, with wavelengths 108.5nm and 30.4nm, in making a transition to ground state. The quantum number n, corresponding to its initial excited state is (for photon of wavelength », energy $E = \frac{1240 eV}{\lambda(\text{ in nm })}$
[12 April 2019 II]

Options:

A. n = 4

B. n = 5

C. n = 7

D. n = 6

Answer: B

Solution:

$E = E_1 + E_2$

$13.6\frac{z^2}{n^2} = \frac{1240}{\lambda_1} + \frac{1240}{\lambda_2}$

or $\frac{13.6(2)^2}{n^2} = 1240\left(\frac{1}{108.5} + \frac{1}{30.4}\right) \times \frac{1}{10^{-9}}$

On solving, n = 5

Question157

The electron in a hydrogen atom first jumps from the third excited state to the second excited state and subsequently to the first excited state. The ratio of the respective wavelengths, $\frac{\lambda_1}{\lambda_2}$, of the photons emitted in this process is :
[12 April 2019 II]

Options:

A. 20/7

B. 27/5

C. 7/5

D. 9/7

Answer: A

Solution:

Solution:

$\frac{1}{\lambda_1} = R\left(\frac{1}{3^2} - \frac{1}{4^2}\right) = \frac{7R}{16 \times 9}$

And $\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$

Now $\frac{\lambda_1}{\lambda_2} = \frac{(5R / 36)}{7R / (16 \times 9)} = \frac{20}{7}$

Question158

Consider an electron in a hydrogen atom, revolving in its second excited state (having radius 4.65 Å). The de- Broglie wavelength of this electron is :
[12 April 2019 II]

Options:

A. 3.5 Å

B. 6.6 Å

C. 12.9 Å

D. 9.7 Å

Answer: D

Solution:

Solution:

$v = \frac{c}{137n} = \frac{c}{137 \times 3}$

$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\left(\frac{m \times c}{3 \times 137}\right)} = \frac{h}{mc} \times (3 \times 137) = 9.7Å$

Question159

In Li^{++}, electron in first Bohr orbit is excited to a level by a radiation of wavelength lambda. When the ion gets deexcited to the ground state in all possible ways (including intermediate emissions), a total of six spectral lines are observed. What is the value of λ?
(Given : $h = 6.63 \times 10^{-34} J\,s$; $c = 3 \times 10^{8} ms^{-1}$)
[10 April 2019 II]

Options:

A. 11.4 nm

B. 9.4 nm

C. 12.3 nm

D. 10.8 nm

Answer: D

Solution:

Solution:

Spectral lines obtained on account of transition from nth orbit to various lower orbits is $\frac{n(n-1)}{2}$

$\Rightarrow 6 = \frac{n(n-1)}{2}$

$\Rightarrow n = 4$

$\Delta E = \frac{hc}{\lambda} = \frac{-Z^2}{n^2}(13.6eV)$

$\Rightarrow \frac{1}{\lambda} = Z^2\left(\frac{13.6eV}{hc}\right)\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$

$= (13.4)(3)^2\left[1 - \frac{1}{16}\right]eV$

$\Rightarrow \lambda = \frac{1242 \times 16}{(13.4) \times (9)(15)} nm \simeq 10.8nm$

Question160

Taking the wavelength of first Balmer line in hydrogen spectrum (n = 3 to n = 2) as 660 nm, the wavelength of the 2^{nd} Balmer line (n = 4 to n = 2) will be;
[9 April 2019 I]

Options:

A. 889.2 nm

B. 488.9 nm

C. 642.7 nm

D. 388.9 nm

Answer: B

Solution:

Solution:

$\frac{1}{\lambda_1} = -R\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$

$\frac{1}{\lambda_2} = R\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{16}$

$\therefore \frac{\lambda_2}{\lambda_1} = \frac{80}{108}$

$\lambda_2 = \frac{80}{108}\lambda_1 = \frac{80}{108} \times 660 = 488.9\text{nm}$

Question161

A He^+ ion is in its first excited state. Its ionization energy is:
[9 April 2019 II]

Options:

A. 48.36 eV

B. 54.40 eV

C. 13.60 eV

D. 6.04 eV

Answer: C

Solution:

$E_n = -13.6\frac{Z^2}{n^2}$

For He^+, $E_2 = \frac{-13.6(2)^2}{2^2} = -13.60\text{eV}$

Ionization energy $= 0 - E_2 = 13.60 eV$

Question162

Radiation coming from transitions n = 2 to n = 1 of hydrogen atoms fall on He^+ ions in n = 1 and n = 2 states. The possible transition of helium ions as they absorb energy from the radiation is : [8 April 2019 I]

Options:

A. $n = 2 \rightarrow n = 3$

B. $n = 1 \rightarrow n = 4$

C. $n = 2 \rightarrow n = 5$

D. $n = 2 \rightarrow n = 4$

Answer: D

Solution:

Solution:
Energy released by hydrogen atom for transition n = 2 to n = 1
$\therefore \Delta E_1 = 13.6 \times \left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3}{4} \times 13.6 eV$
$= 10.2 eV$
This energy is absorbed by He^+ ion in transition from $n = 2$ to $n = n_1$ (say)
$\therefore \Delta E_2 = 13.6 \times 4 \times \left(\frac{1}{4} - \frac{1}{n_1^2}\right) = 10.2 eV$
$\Rightarrow n_1 = 4$
So, possible transition is $n = 2 \rightarrow n = 4$

Question163

A hydrogen atom, initially in the ground state is excited by absorbing a photon of wavelength 980Å. The radius of the atom in the excited state, in terms of Bohr radius a_0 ,will be: [11 April 2019 I]

Options:

A. $25a_0$

B. $9a_0$

C. $16a_0$

D. $4a_0$

Answer: C

Solution:

Solution:

Energy of photon $= \frac{hc}{\lambda} = \frac{12500}{980} = 12.75eV$

Energy of electron in n^{th} orbit is given by

$E\,n = \frac{-13.6}{n^2} \Rightarrow E_n - E_1 = -13.6\left[\frac{1}{n^2}\frac{-1}{1^2}\right]$

$\Rightarrow 12.75 = 13.6\left[\frac{1}{1^2}\frac{-1}{n^2}\right] \Rightarrow n = 4$

∴ Electron will excite to $n = 4$

We know that 'R' $\propto n^2$

∴ Radius of atom will be $16a_0$

Question164

The ratio of the mass densities of nuclei of ^{40}Ca and ^{16}O is close to : [8 April 2019 II]

Options:

A. 1

B. 0.1

C. 5

D. 2

Answer: A

Solution:

Solution:

Nuclear density is independent of atomic number.

Question165

Two radioactive materials A and B 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 A to that of B will be 1 / e after a time : [10 April 2019, I]

Options:

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

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

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

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

Answer: A

Solution:

As, $N = N_0 e^{-\lambda t}$

so, $\frac{N_A}{N_B} = e^{(\lambda_B - \lambda_A)t} = \frac{1}{e} \Rightarrow (\lambda_B - \lambda_A)t = -1$

$\Rightarrow (\lambda_A - \lambda_B) . t = 1$

$\Rightarrow t = \frac{1}{(\lambda_B - \lambda_A)} t = \frac{1}{10\lambda - \lambda} = \frac{1}{9\lambda}$

Question166

Two radioactive substances A and B have decay constants 5 lambda and λ respectively. At t = 0, a sample has the same number of the two nuclei. The time taken for the ratio of the number of nuclei to become $\left(\frac{1}{e}\right)^2$ will be

[10 April 2019, II]

Options:

A. 1 / 2λ

B. 1 / 4λ

C. 1 / λ

D. 2 / λ

Answer: A

Solution:

Solution:

Let N_1 and N_2 be the number of radioactive nuclei of substance at anytime t.

$N_1(\text{ at } t) = N_0 e^{-5\lambda t}$ ....(i)

$N_2(\text{ at } t) = N_0 e^{-\lambda t}$ .....(ii)

Dividing equation (i) by (ii), we get

$\frac{N_1}{N_2} = \frac{1}{e^2} = e^{-4\lambda t} \Rightarrow 4\lambda t = 2$

$\Rightarrow t = \frac{2}{4\lambda} = \left(\frac{1}{2\lambda}\right)$

Question167

An electron from various excited states of hydrogen atom emit radiation to come to the ground state. Let λ_n, λ_g be the de Broglie wavelength of

the electron in the n^{th} state and the ground state respectively. Let Λ_n be the wavelength of the emitted photon in the transition from the n^{th} state to the ground state. For large n, (A, B are constants)
[2018]

Options:

A. $\Lambda_n \approx A + \frac{B}{\lambda_n^2}$

B. $\Lambda_n \approx A + B\lambda_n$

C. $\Lambda_n^2 \approx A + B\lambda_n^2$

D. $\Lambda_n^2 \approx \lambda$

Answer: A

Solution:

Solution:
Wavelength of emitted photon from n^{th} state to the ground state,
$\frac{1}{\Lambda_n} = RZ^2\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$
$\Lambda_n = \frac{1}{RZ^2}\left(1 - \frac{1}{n^2}\right)^{-1}$
Since n is very large, using binomial theorem
$\Lambda_n = \frac{1}{RZ^2}\left(1 + \frac{1}{n^2}\right)$
$\Lambda_n = \frac{1}{RZ^2} + \frac{1}{RZ^2}\left(\frac{1}{n^2}\right)$
As we know, $\lambda_n = \frac{2\pi r}{n} = 2\pi\left(\frac{n^2h^2}{4\pi^2 mZe^2}\right)\frac{1}{n} \propto n$
$\Lambda_n \approx A + \frac{B}{\lambda_n^2}$

Question168

If the series limit frequency of the Lyman series is v_1 , then the series limit frequency of the P-fund series is
[2018]

Options:

A. $25v_L$

B. $16v_L$

C. $v_L / 16$

D. $v_L / 25$

Answer: D

Solution:

$hv_L = E_\infty - E_1$ ...(i)
$hv_f = E_\infty - E_5$ ...(ii)

$E \propto \frac{z^2}{n^2} \Rightarrow \frac{E_5}{E_1} = \left(\frac{1}{5}\right)^2 = \frac{1}{25}$

Eqn(i) / (ii) $\Rightarrow \frac{hv_L}{hv_f} = \frac{E_1}{E_5}$

$\Rightarrow \frac{v_L}{v_f} = \frac{25}{1} \Rightarrow v_f = \frac{v_L}{25}$

Question169

The de-Broglie wavelength (λ_B) associated with the electron orbiting in the second excited state of hydrogen atom is related to that in the ground state (λ_G) by
[Online April 16, 2018]

Options:

A. $\lambda_B = \lambda_{G/3}$

B. $\lambda_B = \lambda_{G/2}$

C. $\lambda_B = 2\lambda_G$

D. $\lambda_B = 3\lambda_G$

Answer: D

Solution:

de-Broglie wavelength, $\lambda = \frac{h}{P}$

$\frac{\lambda_B}{\lambda_G} = \frac{P_a}{P_B} = \frac{mv_G}{mv_B}$

Speed of electron $V \propto \frac{z}{n}$

so $\frac{\lambda_B}{\lambda_G} = \frac{n_B}{n_G} = \frac{3}{1} \Rightarrow \lambda_B = 3\lambda_G$

Question170

The energy required to remove the electron from a singly ionized Helium atom is 2.2 times the energy required to remove an electron from Helium atom. The total energy required to ionize the Helium atom completely is:
[Online April 15, 2018]

Options:

A. 20 eV

B. 79 eV

C. 109 eV

D. 34 eV

Answer: B

Solution:

Solution:

Energy required to remove e^{-} from singly ionized helium atom $= \frac{(13.6)Z^2}{1^2} = 54.4\text{eV}$ $(\because Z = 2)$

Energy required to remove e^{-} from helium atom $= x\text{eV}$
According to question, $54.4\text{eV} = 2.2x \Rightarrow x = 24.73\text{eV}$
Therefore, energy required to ionize helium atom $= (54.4 + 24.73)\text{eV} = 79.12\text{eV}$

Question171

Muon (μ^{-1}) is negatively charged ($|q| = |e|$) with a mass $m_{\mu} = 200m_e$, where m_e is the mass of the electron and e is the electronic charge. If μ^{-1} is bound to a proton to form a hydrogen like atom, identify the correct statements
(A) Radius of the muonic orbit is 200 times smaller than that of the electron
(B) the speed of the μ^{-1} in the nth orbit is $\frac{1}{200}$ times that of the election in the nth orbit
(C) The lonization energy of muonic atom is 200 times more than that of an hydrogen atom
(D) The momentum of the muon in the nth orbit is 200 times more than that of the electron
[Online April 15, 2018]

Options:

A. (A), (B), (D)

B. (B), (D)

C. (C), (D)

D. (A), (C), (D)

Answer: D

Solution:

(A) Radius of muon $= \frac{\text{Radius of hydrogen}}{200}$

Radius of H atom $= r = \frac{\epsilon_0 n^2 h^2}{\pi m e^2}$

Radius of muon $= r_\mu = \frac{\epsilon_0 n^2 h^2}{\pi \times 200 m e^2}$

$r_\mu = \frac{r}{200}$

(B) Velocity relation given is wrong

(C) Ionization energy in $e^- H$ atom

$E = \frac{+me^4}{8 \epsilon_0^2 n^2 h^2}$

$E_\mu = \frac{200 me^4}{8 \epsilon_0^2 n^2 h^2} = 200E$

(D) Momentum of H-atom

$mvr = \frac{nh}{2\pi}$

Hence (A), (C), (D) are correct.

Question172

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: [Online April 15, 2018]

Options:

A. 8 : 27

B. 2 : 3

C. 3 : 2

D. 4 : 9

Answer: C

Solution:

Solution:

Let heavy nucleus breaks into two nuclei of mass m_1 and m_2 and move away with velocities V_1 and V_2 ? respectively.

According to question,

$\frac{V_1}{V_2} = \frac{8}{27}$

$m_1 V_1 = m_2 V_2$ (Law of momentum conservation)

$\Rightarrow \frac{m_1}{m_2} = \frac{V_2}{V_1} = \frac{27}{8}$

$\frac{\rho \times \frac{4}{3}\pi R_1^3}{\rho \times \frac{4}{3}\pi R_2^3} \left(\because \text{density}\ \rho = \frac{\text{mass}}{\text{volume}} \right)$

$\Rightarrow \left(\frac{R_1}{R_2} \right) = \left(\frac{27}{8} \right)^{\frac{1}{3}} = \left(\frac{3}{2} \right)^{3 \times \frac{1}{3}} \therefore \frac{R_1}{R_2} = \frac{3}{2}$

Question173

At some instant, a radioactive sample S_1 having an activity 5μCi has twice the number of nuclei as another sample S_2 which has an activity of 10μCi. The half lives of S_1 and S_2 are
[Online April 16, 2018]

Options:

A. 10 years and 20 years, respectively

B. 5 years and 20 years, respectively

C. 20 years and 10 years, respectively

D. 20 years and 5 years, respectively

Answer: D

Solution:

$S_1 = \frac{dN}{dt} = \lambda_1 N_1 = 5;$
$S_2 = \frac{dN}{dt} = \lambda_2 N_2 = 10$
(Given $N_1 = 2N_2$)
$\lambda_1(2N_2) = 5 \rightarrow (1);$
$\lambda_2 N_2 = 10 \rightarrow (2)$
⇒ dividing (1) & (2)
$\frac{2\lambda_1}{\lambda_2} = \frac{1}{2} \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{1}{4}$
We know that $\lambda = \frac{\ln 2}{t_{1/2}}$
$\therefore \lambda \propto \frac{1}{t_{1/2}}$
$\Rightarrow \frac{t_{1/2}}{t_{1/2}^{1}} = \frac{4}{1}$
$t_{1/2} = 4t_{1/2}^{1}$
$\Rightarrow t_{1/2} = 20$ [half life of s_1]
$t_{1/2}' = 5$ [half life of s_2]

Question174

A solution containing active cobalt $_{27}^{60}Co$ having activity of 0.8μCi and decay constant λ is injected in an animal's body. If $1cm^3$ 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? ($1Ci = 3.7 \times 10^{10}$ decay per second and at $t = 10hrs$ $e^{-\lambda t} = 0.84$)
[Online April 15, 2018]

Options:

A. 6 litres

B. 7 litres

C. 4 litres

D. 5 litres

Answer: D

Solution:

Solution:
Let initial activity $= N_o = 0.8 \mu ci \; 0.8 \times 3.7 \times 10^4 d\,ps$
Activity in $1 cm^3$ of blood at $t = 10 hr$
$n = \frac{300}{60} d\,ps = 5 d\,ps$
N = Activity of whole blood at time $t = 10 hr$
Total volume of the blood in the person, $V = \frac{N}{n}$
$= \frac{N_0 e - \lambda t}{n} = \frac{0.8 \times 3.7 \times 10^4 \times 0.7927}{5} \cong$ 5 litres

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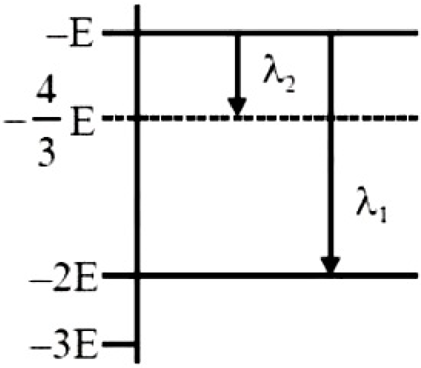
Question175

Some energy levels of a molecule are shown in the figure. The ratio of the wavelengths $r = \lambda_1 / \lambda_2$, is given by



[2017]

Options:

A. $r = \frac{3}{4}$

B. $r = \frac{1}{3}$

C. $r = \frac{4}{3}$

D. $r = \frac{2}{3}$

Answer: B

Solution:

From energy level diagram, using $\Delta E = \frac{hc}{\lambda}$

For wavelength $\lambda_1 \Delta E = -E - (-2E) = \frac{hc}{\lambda_1}$

$\therefore \lambda_1 = \frac{hc}{E}$

For wavelength $\lambda_2 \Delta E = -E - \left(-\frac{4E}{3}\right) = \frac{hc}{\lambda_2}$

$\therefore \lambda_2 = \frac{hc}{\left(\frac{E}{3}\right)}$

$\therefore r = \frac{\lambda_1}{\lambda_2} = \frac{1}{3}$

Question176

The acceleration of an electron in the first orbit of the hydrogen atom (z = 1) is :
[Online April 9, 2017]

Options:

A. $\frac{h^2}{\pi^2 m^2 r^3}$

B. $\frac{h^2}{8\pi^2 m^2 r^3}$

C. $\frac{h^2}{4\pi^2 m^2 r^3}$

D. $\frac{h^2}{4\pi m^2 r^3}$

Answer: C

Solution:

Solution:

Speed of electron in first orbit (n = 1) of hydrogen atom (z = 1),

$v = \frac{e^2}{2\varepsilon_0 h}$

radius of Bohr's first orbit,

$r = \frac{h^2 \varepsilon_0}{\pi m e^2} \Rightarrow \varepsilon_0 = \frac{r \pi m e^2}{h^2}$ .... (i)

Acceleration of electron,

$\frac{v^2}{r} = \frac{e^4}{4\varepsilon_0^2 h^2} \times \frac{\pi m e^2}{h^2 \varepsilon_0}$

$= \frac{e^4 \times \pi m e^2}{4h^4 \varepsilon_0^3}$....... (ii)

eliminating ε_0 from eq (ii),

$= \frac{e^4 \pi m e^2 h^6}{4h^4 r^3 \pi^3 m^3 e^6}$ from eq^n(i)

$= \frac{h^2}{4\pi^2 m^2 r^3}$

Question177

According to Bohr's theory, the time averaged magnetic field at the centre (i.e. nucleus) of a hydrogen atom due to the motion of electrons in the n^{th} orbit is proportional to : (n = principal quantum number) [Online April 8, 2017]

Options:

A. n^{-4}

B. n^{-5}

C. n^{-3}

D. n^{-2}

Answer: D

Solution:

Solution:
Magnetic field at the centre of nucleus of H-atom,
$B = \frac{\mu_0 I}{2r}$ ..... (i)
According to Bohr's model, radius of orbit $r \propto n^2$ from eq. (i) we can also write as $B \propto n^{-2}$

Question178

Imagine that a reactor converts all given mass into energy and that it operates at a power level of 10^9 watt. The mass of the fuel consumed per hour in the reactor will be : (velocity of light, c is $3 \times 10^8 m / s$) [Online April 9, 2017]

Options:

A. 0.96gm

B. 0.8gm

C. 4×10^{-2}gm

D. 6.6×10^{-5}gm

Answer: C

Solution:

Solution:
Power level of reactor, $P = \frac{E}{\Delta t} = \Delta mc^2 \Delta t$
mass of the fuel consumed per hour in the reactor,

$\frac{\Delta m}{\Delta t} = \frac{P}{c^2} = \frac{10^9}{(3 \times 10^8)^2} = 4 \times 10^{-2} gm$

Question179

Two deuterons undergo nuclear fusion to form a Helium nucleus. Energy released in this process is : (given binding energy per nucleon for deuteron=1.1 MeV and for helium=7.0 MeV) [Online April 8, 2017]

Options:

A. 30.2 MeV

B. 32.4 MeV

C. 23.6 MeV

D. 25.8 MeV

Answer: C

Solution:

Solution:
${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4$ Total binding energy of two deuterium nuclei $= 1.1 \times 4 = 4.4 MeV$
Binding energy of a $({}_2He^4)$ nuclei $= 4 \times 7 = 28 MeV$
Energy released in this process $= 28 - 4.4 = 23.6 MeV$

Question180

A radioactive nucleus A with a half life T, decays into a nucleus B. At t = 0, there is no nucleus B. At sometime, the ratio of the number of B to that of A is 0.3. Then, t is given by [2017]

Options:

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

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

C. $t = T \frac{\log 2}{\log 1.3}$

D. $t = \frac{\log 1.3}{\log 2}$

Answer: D

Solution:

Let initially there are total N_0 number of nuclei At time t

$\frac{N_B}{N_A} = 0.3$(given)

$\Rightarrow N_B = 0.3N_A$

$N_0 = N_A + N_B = N_A + 0.3N_A$

$\therefore N_A = \frac{N_0}{1.3}$

As we know $N_t = N_0 e^{-\lambda t}$

or, $\frac{N_0}{1.3} = N_0 e^{-\lambda t}$

$\frac{1}{1.3} = e^{-\lambda t} \Rightarrow \ln(1.3) = \lambda t$

or, $t = \frac{\ln(1.3)}{\lambda} \Rightarrow t = \frac{\ln(1.3)}{\frac{\ln(2)}{T}} = \frac{\ln(1.3)}{\ln(2)}T$

Question181

A hydrogen atom makes a transition from n = 2 to n = 1 and emits a photon. This photon strikes a doubly ionized lithium atom (z = 3) in excited state and completely removes the orbiting electron. The least quantum number for the excited state of the ion for the process is : [Online April 9, 2016]

Options:

A. 2

B. 4

C. 5

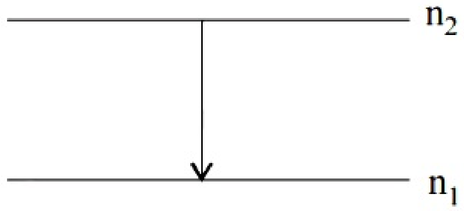
D. 3

Answer: B

Solution:

Solution:

A hydrogen atom makes a transition from n = 2 to n = 1



Then wavelength $= Rcz^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = Rc(1)^2\left[1 - \frac{1}{4}\right]$

$\lambda = Rc\left[\frac{3}{4}\right]$ ......(1)

For ionized lithium

$\lambda = Rc(3)^2\left[\frac{1}{n^2}\right] = Rc9\left[\frac{1}{n^2}\right]$ ......(2)

$Rc\left[\frac{3}{4}\right] = Rc9\left[\frac{1}{n^2}\right]$

$\Rightarrow \frac{3}{4} = \frac{9}{n^2} \Rightarrow n = \sqrt{12} = 2\sqrt{3}$

∴ The least quantum number must be 4.

Question182

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 number of A and B nuclei will be : [2016]

Options:

A. 1 : 4

B. 5 : 4

C. 1 : 16

D. 4 : 1

Answer: B

Solution:

Solution:
For $A_{t/2} = 20\,\text{min}$, t = 80 min, number of half lifes $n = 4$

∴ Nuclei remaining $= \frac{N_0}{2^4}$. Therefore nuclei decayed $= N_0 - \frac{N_0}{2^4}$

For $B_{t1/2} = 40\text{min.}$, t = 80min, number of half lifes $n = 2$

∴ Nuclei remaining $= \frac{N_0}{2^2}$. Therefore nuclei decayed $= N_0 - \frac{N_0}{2^2}$

$$\therefore \text{Required ratio } = \frac{N_0 - \frac{N_0}{2^4}}{N_0 - \frac{N_0}{2^2}} = \frac{1 - \frac{1}{16}}{1 - \frac{1}{4}} = \frac{15}{16} \times \frac{4}{3} = \frac{5}{4}$$

Question183

As an electron makes a transition from an excited state to the ground state of a hydrogen - like atom/ion : [2015]

Options:

A. kinetic energy decreases, potential energy increases but total energy remains same

B. kinetic energy and total energy decrease but potential energy increases

C. its kinetic energy increases but potential energy and total energy decrease

D. kinetic energy, potential energy and total energy decrease

Answer: C

Solution:

Kinetic energy of electron is

K.E. $\propto \left(\frac{Z}{N}\right)^2$

When the electron makes transition from excited state to ground state, then n increases and kinetic energy increases.

Total energy = – KE

∴ Total energy also decreases.

Potential energy is lowest for ground state.

Question184

The de–Broglie wavelength associated with the electron in the n = 4 level is :
[Online April 11, 2015]

Options:

A. $\frac{1}{4}$ th of the de–Broglie wavelength of the electron in the ground state.

B. four times the de–Broglie wavelength of the electron in the ground state

C. two times the de–Broglie wavelength of the electron in the ground state

D. half of the de–Broglie wavelength of the electron in the ground state

Answer: B

Solution:

Solution:

De-Broglie wavelength of electron $\lambda = \frac{h}{mV}$

As we know, $V \propto \frac{1}{n}$

So, $\lambda \propto n$

$\lambda_4 = 4\lambda_1$

λ_1 is the de-Broglie wavelength of the electron in the ground state.

Question185

If one were to apply Bohr model to a particle of mass ‘m’ and charge ‘q’ moving in a plane under the influence of a magnetic field ‘B’, the energy of the charged particle in the nth level will be :
[Online April 10, 2015]

Options:

A. $n\left(\frac{hqB}{2\pi m}\right)$

B. $n\left(\frac{hqB}{8\pi m}\right)$

C. $n\left(\frac{hqB}{4\pi m}\right)$

D. $n\left(\frac{hqB}{\pi m}\right)$

Answer: C

Solution:

$qVB = \frac{mv^2}{r}$ ....(i)

$\frac{nh}{2\pi} = mvr$ ....(ii)

Multiplying equation (i) and (ii),

$\frac{qBnh}{2\pi} = m^2v^2$

Now multiplying both sides by $\frac{1}{2m}$,

$n\frac{qBh}{4\pi m} = \frac{1}{2}mv^2$

i.e. $KE = n\left[\frac{qBh}{4\pi m}\right]$

Question186

Let N_β be the number of β particles emitted by 1 gram of Na^{24} radioactive nuclei (half life = 15hrs) in 7.5 hours, N_β is close to (Avogadro number = 6.023×10^{23} / g. mole)
[Online April 11, 2015]

Options:

A. 6.2×10^{21}

B. 7.5×10^{21}

C. 1.25×10^{22}

D. 1.75×10^{22}

Answer: B

Solution:

We know that $N_\beta = N_0(1 - e^{-\lambda t})$

$N_\surd = \frac{6.023 \times 10^{23}}{24}\left[1 - e\frac{\ln 2}{15} \times 7.5\right]$

on solving we get,

$N_\beta = 7.4 \times 10^{21}$

Question187

The radiation corresponding to 3 → 2 transition of hydrogen atom falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of 3×10^{-4}T . If the radius of the largest circular path followed by these electrons is 10.0mm, the work function of the metal is close to:
[2014]

Options:

A. 1.8 eV

B. 1.1 eV

C. 0.8 eV

D. 1.6 eV

Answer: B

Solution:

Solution:
Radius of circular path followed by electron is given by,
$r = \frac{mv}{qB} = \frac{\sqrt{2meV}}{eB} = \frac{1}{B}\sqrt{\frac{2m}{e}V}$
$\Rightarrow V = \frac{B^2r^2e}{2m} = 0.8V$
For transition between 3 to 2.
$E = 13.6\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{13.6 \times 5}{36} = 1.88eV$
Work function $= 1.88eV - 0.8eV = 1.08eV \approx 1.1eV$

Question188

Hydrogen $({}_1H^1)$, Deuterium $({}_1H^2)$, singly ionised Helium$({}_2He^4)^+$ and doubly ionised lithium $({}_3Li^6)^{++}$ all have one electron around the nucleus. Consider an electron transition from n = 2 to n = 1. If the wavelengths of emitted radiation are λ_1, λ_2, λ_3 and λ_4 respectively then approximately which one of the following is correct?
[2014]

Options:

A. $4\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

B. $\lambda_1 = 2\lambda_2 = 2\lambda_3 = \lambda_4$

C. $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

D. $\lambda_1 = 2\lambda_2 = 3\lambda_3 = 4\lambda_4$

Answer: C

Solution:

Wave number $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n^2}\right]$

$\Rightarrow \lambda \propto \frac{1}{Z^2}$

$\therefore \lambda Z^2 =$ constant

By question $n = 1$ and $n_1 = 2$

Then, $\lambda_1 = \lambda_2 = 4\lambda_3 = 9\lambda_4$

Question189

Match List - I (Experiment performed) with List-II (Phenomena discovered/associated) and select the correct option from the options given below the lists:

	List - I		List - II
(1)	Davisson and Germer experiment	(i)	Wave nature of electrons
(2)	Millikan's oil drop experiment	(ii)	Charge of an electron
(3)	Rutherfordexperiment	(iii)	Quantisation of energy levels
(4)	Franck-Hertz experiment	(iv)	Existence of nucleus

[Online April 19, 2014]

Options:

A. (1)-(i), (2)-(ii), (3)-(iii), (4)-(iv)

B. (1)-(i), (2)-(ii), (3)-(iv), (4)-(iii)

C. (1)-(iii), (2)-(iv), (3)-(i), (4)-(ii)

D. (1)-(iv), (2)-(iii), (3)-(ii), (4)-(i)

Answer: B

Solution:

(1) Davisson and Gemner experiment-wave nature of electrons.
(2) Millikan’s oil drop experiment - charge of an electron.
(3) Rutherford experiment - Existance of nucleus.
(4) Frank-Hertz experiment - Quantisation of energy levels.

Question190

The binding energy of the electron in a hydrogen atom is 13.6 eV, the energy required to remove the electron from the first excited state of Li^{++} is:
[Online April 9, 2014]

Options:

A. 122.4 eV

B. 30.6 eV

C. 13.6 eV

D. 3.4 eV

Answer: B

Solution:

For first excited state, $n = 2$ and for $Li^{++} Z = 3$

$$E_n = \frac{13.6}{n^2} \times Z^2 = \frac{13.6}{4} \times 9 = 30.6 eV$$

Question191

A piece of wood from a recently cut tree shows 20 decays per minute. A wooden piece of same size placed in a museum (obtained from a tree cut many years back) shows 2 decays per minute. If half life of C^{14} is 5730 years, then age of the wooden piece placed in the museum is approximately:
[Online April 19, 2014]

Options:

A. 10439 years

B. 13094 years

C. 19039 years

D. 39049 years

Answer: C

Solution:

Given: $\frac{dN_0}{dt} = 20$ decays /min

$$\frac{dN}{dt} = 2 \text{ decays / min}$$

$T_{1/2}$ = 5730 years
As we know,
$N = N_0 e^{-\lambda t}$
$\log \frac{N_0}{N} = \lambda t$
$\therefore t = \frac{1}{\lambda} \log \frac{N_0}{N}$
$= \frac{2.303 \times T_{1/2}}{0.693} \times \log_{10} \frac{N_0}{N}$
But $\frac{\frac{dN_0}{dt}}{\frac{dN}{dt}} = \frac{N_0}{N} = \frac{20}{2} = 10$
$\therefore t = \frac{2.303 \times 5730}{0.693} \times 1$
= 19039 years

Question192

A piece of bone of an animal from a ruin is found to have ^{14}C activity of 12 disintegrations per minute per gm of its carbon content. The ^{14}C activity of a living animal is 16 disintegrations per minute per gm. How long ago nearly did the animal die? (Given half life of ^{14}C is $t_{1/2}$ = 5760 years)
[Online April 12, 2014]

Options:

A. 1672 years

B. 2391 years

C. 3291 years

D. 4453 years

Answer: B

Solution:

Given, for ^{14}C
$A_0 = 16$ dis $min^{-1} g^{-1}$
$A = 12$ dis $min^{-1} g^{-1}$
$t_{1/2}$ = 5760 years
Now, $\lambda = \frac{0.693}{t_{1/2}}$
$\lambda = \frac{0.693}{5760}$ per year
Then, from, $t = \frac{2.303}{\lambda} \log_{10} \frac{A_0}{A}$
$= \frac{2.303 \times 5760}{0.693} \log_{10} \frac{16}{12}$
$= \frac{2.303 \times 5760}{0.693} \log_{10} 1.333$
$= \frac{2.303 \times 5760 \times 0.1249}{0.693}$ = 2390.81 ≈ 2391 years.

Question193

A radioactive nuclei with decay constant $\frac{0.5}{s}$ is being produced at a constant rate of 100 nuclei/s. If at t = 0 there were no nuclei, the time when there are 50 nuclei is:
[Online April 11, 2014]

Options:

A. $1 s$

B. $2 \ln\left(\frac{4}{3}\right) s$

C. $\ln 2 s$

D. $\ln\left(\frac{4}{3}\right) s$

Answer: B

Solution:

Solution:
Let N be the number of nuclei at any time t then,
$\frac{dN}{dt} = 100 - \lambda N$ or $\int_0^N \frac{dN}{(100 - \lambda N)} = \int_0^t dt$
$-\frac{1}{\lambda}[\log(100 - \lambda N)]_0^N = t$
$\log(100 - \lambda N) - \log 100 = -\lambda t$
$\log \frac{100 - \lambda N}{100} = -\lambda t$
$\frac{100 - \lambda N}{100} = e^{-\lambda t}$ $1 - \lambda N 100 = e^{-\lambda t}$
$N = \frac{100}{\lambda}(1 - e^{-\lambda} t)$
As, N = 50 and $\lambda = 0.5$ / sec
$\therefore 50 = \frac{100}{0.5}(1 - e^{-0.5t})$
Solving we get,
$t = 2 \ln\left(\frac{4}{3}\right)$ sec

Question194

Ina hydrogen like atom electron make transition from an energy level with quantum number n to another with quantum number (n − 1). If n> > 1, the frequency of radiation emitted is proportional to :
[2013]

Options:

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

B. $\frac{1}{n^2}$

C. $\frac{1}{n^3/2}$

D. $\frac{1}{n^3}$

Answer: D

Solution:

$\Delta E = hv$

$v = \frac{\Delta E}{h} = k\left[\frac{1}{(n-1)^2} - \frac{1}{n^2}\right] = \frac{k(2n-1)}{n^2(n-1)^2}$

$\approx \frac{2k}{n^3}$ or $v \propto \frac{1}{n^3}$

Question195

A 12.5 eV electron beam is used to bombard gaseous hydrogen at room temperature. It will emit : [Online April 25, 2013]

Options:

A. 2 lines in the Lyman series and 1 line in the Balmarseries

B. 3 lines in the Lyman series

C. 1 line in the Lyman series and 2 lines in the Balmar series

D. 3 lines in the Balmer series

Answer: A

Solution:

Solution:

$E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{12.5 \times 1.6 \times 10^{-19}} = 993 A°$

$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

(where Rydberg constant, $R = 1.097 \times 10^7$)

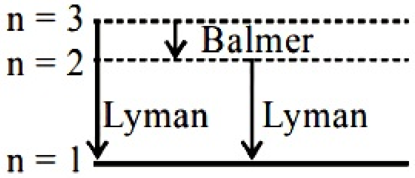
or, $\frac{1}{993 \times 10^{-10}} = 1.097 \times 10^7\left(\frac{1}{1^2} - \frac{1}{n_2^2}\right)$

Solving we get $n_2 = 3$

Spectral lines

Total number of spectral lines $= 3$

Two lines in Lyman series for $n_1 = 1, n_2 = 2$ and $n_1 = 1$ $n_2 = 3$ and one in Balmer series for $n_1 = 2, n_2 = 3$



Question196

In the Bohr's model of hydrogen-like atom the force between the nucleus and the electron is modified as $F = \frac{e^2}{4\pi\varepsilon_0}\left(\frac{1}{r^2} + \frac{\beta}{r^3}\right)$, where β is a constant. For this atom, the radius of the n^{th} orbit in terms of the Bohr radius $\left(a_0 = \frac{\varepsilon_0 h^2}{m\pi e^2}\right)$ is:

[Online April 23, 2013]

Options:

A. $r_n = a_0 n - \beta$

B. $r_n = a_0 n^2 + \beta$

C. $r_n = a_0 n^2 - \beta$

D. $r_n = a_0 n + \beta$

Answer: C

Solution:

As $F = \frac{mv^2}{r} = \frac{e^2}{4\pi\in_0}\left(\frac{1}{r^2} + \beta r^3\right)$

and $mvr = \frac{nh}{2\pi} \Rightarrow v = \frac{nh}{2\pi mr}$

$\therefore m\left(\frac{nh}{2\pi mr}\right)^2 \times \frac{1}{r} = \frac{e^2}{4\pi\in_0}\left(\frac{1}{r^2} + \frac{\beta}{r^3}\right)$

or, $\frac{1}{r^2} + \frac{\beta}{r^3} = \frac{mn^2h^2 4\pi\in_0}{4\pi^2 m^2 e^2 r^3}$

or, $\frac{a_0 n^2}{r^3} = \frac{1}{r^2} + \frac{\beta}{r^3}$ $\left(\because a_0 = \frac{\in_0 h^2}{m\pi e^2} \text{Given} \right)$

For n^{th} atom

$\therefore r_n = a_0 n^2 - \beta$

Question197

Orbits of a particle moving in a circle are such that the perimeter of the orbit equals an integer number of deBroglie wavelengths of the particle. For a charged particle moving in a plane perpendicular to a magnetic field, the radius of the n^{th} orbital will therefore be proportional to :

[Online April 22, 2013]

Options:

A. n^2

B. n

C. $n^{1/2}$

D. $n^{1/4}$

Answer: C

Solution:

According to the question,

$2\pi r = n\lambda = \frac{nh}{p} = \frac{nh}{mv}$

or $mvr = \frac{nh}{2\pi}$ or $mv = \frac{nh}{2\pi r}$

$F = qv_B = \frac{mv^2}{r}$ or, $q_B = \frac{mv}{r} = \frac{nh}{2\pi r \cdot r}$

or, $r^2 = \frac{nh}{2\pi qB}$ or, $r = \sqrt{\frac{nh}{2\pi qB}}$

i.e., $r \propto n^{1/2}$

Question198

In the Bohr model an electron moves in a circular orbit around the proton. Considering the orbiting electron to be a circular current loop, the magnetic moment of the hydrogen atom, when the electron is in n^{th} excited state, is :
[Online April 9, 2013]

Options:

A. $\left(\frac{e}{2m}\frac{n^2h}{2\pi}\right)$

B. $\left(\frac{e}{m}\right)\frac{nh}{2\pi}$

C. $\left(\frac{e}{2m}\right)\frac{nh}{2\pi}$

D. $\left(\frac{e}{m}\right)\frac{n^2h}{2\pi}$

Answer: C

Solution:

Solution:

Magnetic moment of the hydrogen atom, when the electron is in n^{th} excited state, i.e., $n' = (n + 1)$

As magnetic moment $M_n = I_nA = i_n(\pi r_n^2)$

$i_n = eV_n = \frac{mz^2e^5}{4\varepsilon_0^2n^3h^3}$

$r_n = \frac{n^2h^2}{4\pi^2kzme^2}\left(k = \frac{1}{4\pi\epsilon_0}\right)$

Solving we get magnetic moment of the hydrogen atom for n^{th} excited state

$M_{n'} = \left(\frac{e}{2m}\right)\frac{nh}{2\pi}$

Question199

When Uranium is bombarded with neutrons, it undergoes fission. The fission reaction can be written as :
${}_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3x + Q$ (energy)
where three particles named x are produced and energy Q is released. What is the name of the particle x ?
[Online April 9, 2013]

Options:

A. electron

B. α-particle

C. neutron

D. neutrino

Answer: C

Solution:

Nuclear fission equation
${}_{92}U^{135} + {}_{0}n^{1} \rightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3{}_{0}n^{1}$ + Q (energy)
Hence particle x is neutron.

Question200

The half-life of a radioactive element A is the same as the mean-life of another radioactive element B. Initially both substances have the same number of atoms, then :
[Online April 22, 2013]

Options:

A. A and B decay at the same rate always.

B. A and B decay at the same rate initially.

C. A will decay at a faster rate than B.

D. B will decay at a faster rate than A.

Answer: D

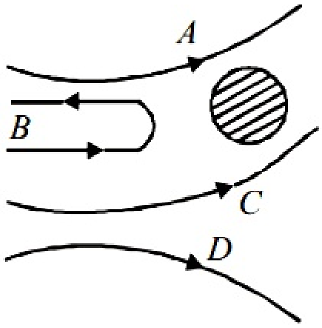
Solution:

$(T_{1/2})_A = (t_{mean})_B$

$\Rightarrow \frac{0.693}{\lambda_A} = \frac{1}{\lambda_B} \Rightarrow \lambda_A = 0.693\lambda_B$
or $\lambda_A < \lambda_B$
Also rate of decay $= \lambda N$
Initially number of atoms (N) of both are equal but since $\lambda_B > \lambda_A$, therefore B will decay at a faster rate than A.

Question201

In the Rutherford experiment, a-particles are scattered from a nucleus as shown. Out of the four paths, which path is not possible?



[Online May 7, 2012]

Options:

A. D

B. B

C. C

D. A

Answer: C

Solution:

Solution:
As α -particles are doubly ionised helium He^{++} i.e. Positively charged and nucleus is also positively charged and we know that like charges repel each other.

Question202

Hydrogen atom is excited from ground state to another state with principal quantum number equal to 4. Then the number of spectral lines in the emission spectra will be :
[2012]

Options:

A. 2

B. 3

C. 5

D. 6

Answer: D

Solution:

For ground state, the principal quantum no. (n) = 1.
Principal quantum number 4 belongs to 3rd excited state.
The possible number of the spectral lines from a state n to ground state is
$= \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$

Question203

A diatomic molecule is made of two masses m_1 and m_2 which are separated by a distance r. If we calculate its rotational energy by applying Bohr's rule of angular momentum quantization, its energy will be given by: (n is an integer) [2012]

Options:

A. $\frac{(m_1 + m_2)^2 n^2 h^2}{2{m_1}^2 {m_2}^2 r^2}$

B. $\frac{n^2 h^2}{2(m_1 + m_2) r^2}$

C. $\frac{2n^2 h^2}{(m_1 + m_2) r^2}$

D. $\frac{(m_1 + m_2) n^2 h^2}{2 m_1 m_2 r^2}$

Answer: D

Solution:

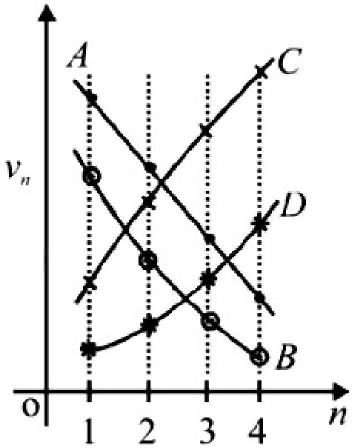
Solution:
The energy of the system of two atoms of diatomic molecule $E = \frac{1}{2} I \omega^2$
where I = moment of inertia
$\omega =$ Angular velocity $= \frac{L}{I}$,
L = Angular momentum
$I = \frac{1}{2}(m_1 {r_1}^2 + m^2 {r_2}^2)$
Thus, $E = \frac{1}{2}(m_1 {r_1}^2 + m_2 {r_2}^2)\omega^2$ .... (i)
$E = \frac{1}{2}(m_1 {r_1}^2 + m_2 {r_2}^2)\frac{L^2}{I^2}$
$L = nh$
(According to Bohr's Hypothesis)
$E = \frac{1}{2}(m_1 {r_1}^2 + m_2 {r_2}^2)\frac{L^2}{(m_1 {r_1}^2 + m_2 {r_2}^2)^2}$

$$E = \frac{1}{2}\frac{L^2}{(m_1 r_1^2 + m_2 r_2^2)} = \frac{n^2h^2}{8\pi^2(m_1 r_1^2 + m_2 r_2^2)}$$

$$E = \frac{(m_1 + m_2)n^2h^2}{8\pi^2 r^2 m_1 m_2}$$

Question204

Which of the plots shown in the figure represents speed (v_n) of the electron in a hydrogen atom as a function of the principal quantum number (n)?



[Online May 26, 2012]

Options:

A. B

B. D

C. C

D. A

Answer: A

Solution:

Solution:

Velocity of electron in n^{th} orbit of hydrogen atom is given by :

$V_n = \frac{2\pi K Z e^2}{nh}$

Substituting the values we get,

$V_n = \frac{2.2 \times 10^6}{n} m/s$ or $V_n \propto \frac{1}{n}$

As principal quantum number increases, velocity decreases.

Question205

A doubly ionised Li atom is excited from its ground state (n = 1) to n = 3 state. The wavelengths of the spectral lines are given by λ_{32}, λ_{31} and λ_{21}. The ratio $\lambda_{32} / \lambda_{31}$ and $\lambda_{21} / \lambda_{31}$ are, respectively

[Online May 12,2012]

Options:

A. 8.1, 0.67

B. 8.1, 1.2

C. 6.4, 1.2

D. 6.4, 0.67

Answer: C

Solution:

$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ where R = Rydberg constant

$\frac{1}{\lambda_{32}} = \left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5}{36} \Rightarrow \lambda_{32} = \frac{36}{5}$

Similarly solving for λ_{31} and λ_{21}

$\lambda_{31} = \frac{9}{8}$ and $\lambda_{21} = \frac{4}{3}$

$\therefore \frac{\lambda_{32}}{\lambda_{31}} = 6.4$ and $\frac{\lambda_{21}}{\lambda_{31}} \simeq 1.2$

Question206

A hypothetical atom has only three energy levels. The ground level has energy, $E_1 = -8eV$. The two excited states have energies, $E_2 = -6eV$ and $E_3 = -2eV$. Then which of the following wavelengths will not be present in the emission spectrum of this atom?
[Online May 12,2012]

Options:

A. 207 nm

B. 465 nm

C. 310 nm

D. 620 nm

Answer: B

Solution:

Solution:

$E = \frac{hc}{\lambda}$

Question207

The electron of a hydrogen atom makes a transition from the $(n + 1)^{th}$ orbit to the n^{th} orbit. For large n the wavelength of the emitted radiation is proportional to [Online May 7,2012]

Options:

A. n

B. n^3

C. n^4

D. n^2

Answer: B

Solution:

Solution:
If $n_1 = n$ and $n_2 = n + 1$
Maximum wavelength $\lambda_{max} = \frac{n^2(n+1)^2}{(2n+1)R}$
Therefore, for large n, $\lambda_{max} \propto n^3$

Question208

Assume that a neutron breaks into a proton and an electron. The energy released during this process is : (mass of neutron $= 1.6725 \times 10^{-27}$kg, mass of proton $= 1.6725 \times 10^{-27}$kg, mass of electron $= 9 \times 10^{-31}$kg) [2012]

Options:

A. 0.51 MeV

B. 7.10 MeV

C. 6.30 MeV

D. 5.4 MeV

Answer: A

Solution:

Solution:
${}_0^1n \rightarrow {}_1^1H + {}_{-1}e^0 + \bar{v} + Q$
The mass defect during the process
$\Delta m = m_n - m_H - m_e = 1.6725 \times 10^{-27} - (1.6725 \times 10^{-27} + 9 \times 10^{-31} kg)$
$= -9 \times 10^{31}$
The energy released during the process

$E = \Delta mc^2$
$E = 9 \times 10^{-31} \times 9 \times 10^{16} = 81 \times 10^{-15}$ Joules
$E = \dfrac{81 \times 10^{-15}}{1.6 \times 10^{-19}} = 0.511\text{M eV}$

Question209

Ionisation energy of Li (Lithium) atom in ground state is 5.4 eV. Binding energy of an electron in Li^+ ion in ground state is 75.6 eV. Energy required to remove all three electrons of Lithium (Li) atom is [Online May 19, 2012]

Options:

A. 81.0 eV

B. 135.4 eV

C. 203.4 eV

D. 156.6 eV

Answer: D

Solution:

Solution:

Question210

The counting rate observed from a radioactive source at t = 0 was 1600 counts s^{-1}, and t = 8 s, it was 100 counts s^{-1}. The counting rate observed as counts s^{-1} at t = 6 s will be [Online May 26, 2012]

Options:

A. 250

B. 400

C. 300

D. 200

Answer: D

Solution:

Solution:
As we know,

$\left[\frac{N}{N_0}\right] = \left[\frac{1}{2}\right]^n$ ....(i)
n = no. of half life
N - no. of atoms left
N_0 - initial no. of atoms
By radioactive decay law,
$\frac{dN}{dt} = kN$
k - disintegration constant
$\therefore \frac{\frac{dN}{dt}}{\frac{dN_0}{dt}} = \frac{N}{N_0}$ ......(ii)
From (i) and (ii) we get
$\frac{\frac{dN}{dt}}{\frac{dN_0}{dt}} = \left[\frac{1}{2}\right]^n$
or, $\left[\frac{100}{1600}\right] = \left[\frac{1}{2}\right]^n \Rightarrow \left[\frac{1}{2}\right]^4 = \left[\frac{1}{2}\right]^n$
$\therefore$ n = 4, Therefore, in 8 seconds 4 half life had occurred in which counting rate reduces to 100 counts s^{-1}.
$\therefore$ Half life, $T_{\frac{1}{2}} = 2\,\text{sec}$
In 6 sec, 3 half life will occur
$\therefore \left[\frac{\frac{dN}{dt}}{1600}\right] = \left[\frac{1}{2}\right]^3 \Rightarrow \frac{dN}{dt} = 200\,\text{counts}\,s^{-1}.$

Question211

The decay constants of a radioactive substance for α and β emission are λ_α and λ_β respectively. If the substance emits α and β simultaneously, then the average half life of the material will be [Online May 19, 2012]

Options:

A. $\frac{2T_\alpha T_\beta}{T_\alpha + T_\beta}$

B. $T_\alpha + T_\beta$

C. $\frac{T_\alpha T_\beta}{T_\alpha + T_\beta}$

D. $\frac{1}{2}(T_\alpha + T_\beta)$

Answer: C

Solution:

Solution:
$T_{av} = \frac{T_\alpha T_\beta}{T_\alpha + T_\beta}$
If α and B are emitted simultaneously.

Question212

Which of the following Statements is correct?
[Online May 12, 2012]

Options:

A. The rate of radioactive decay cannot be controlled but that of nuclear fission can be controlled.

B. Nuclear forces are short range, attractive and charge dependent.

C. Nuclei of atoms having same number of neutrons are known as isobars.

D. Wavelength of matter waves is given by de Broglie formula but that of photons is not given by the sameformula

Answer: A

Solution:

Solution:
Radioactive decay is a continuous process. Rate of radioactive decay cannot be controlled. Nuclear fission can be controlled but not of nuclear fusion.

Question213

A sample originally contained 10^{20} radioactive atoms, which emit α -particles. The ratio of α -particles emitted in the third year to that emitted during the second year is 0.3. How many α -particles were emitted in the first year?
[Online May 7, 2012]

Options:

A. 3×10^{18}

B. 3×10^{19}

C. 5×10^{18}

D. 7×10^{19}

Answer: B

Solution:

Solution:

Question214

Energy required for the electron excitation in Li^{++} from the first to the third Bohr orbit is :
[2011]

Options:

A. 36.3 eV

B. 108.8 eV

C. 122.4 eV

D. 12.1 eV

Answer: B

Solution:

Solution:
Energy of excitation (ΔE) is
$\Delta E = 13.6z^2\left(\frac{1}{n_1} - \frac{1}{n_2}\right)eV$
$\Rightarrow \Delta E = 13.6(3)^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = 108.8eV$

Question215

After absorbing a slowly moving neutron of mass m_N (momentum ≈ 0) a nucleus of mass M breaks into two nuclei of masses m_1 and $5m_1(6m_1 = M + m_N)$ respectively. If the de Broglie wavelength of the nucleus with mass m_1 is λ, the de Broglie wavelength of the nucleus will be
[2011]

Options:

A. 5λ

B. λ / 5

C. λ

D. 25λ

Answer: C

Solution:

Solution:
Initial momentum of system, $p_i = 0$
Let p_1 and p_2 be the momentum of broken nuclei of masses m_1 and $5m_1$ respectively.
$p_f = p_1 + p_2$
From the conservation of momentum
$p_i = p_f$

$0 = p_1 + p_2$
$p_1 = -p_2$
From de Broglie relation, wavelength
$\lambda_1 = \frac{h}{p_1}$ and $\lambda_2 = \frac{h}{p_2}$
$|\lambda_1| = |\lambda_2|$
$\lambda_1 = \lambda_2 = \lambda$.

Question216

The half life of a radioactive substance is 20 minutes. The approximate time interval $(t_2 - t_1)$ between the time t_2 when $\frac{2}{3}$ of it had decayed and time t_1 when $\frac{1}{3}$ of it had decayed is :
[2011]

Options:

A. 14 min

B. 20 min

C. 28 min

D. 7 min

Answer: B

Solution:

Number of undecayed atom after time t_2 ;
$\frac{N_0}{3} = N_0 e^{-\lambda t_2}$ .....(i)
Number of undecayed atom after time t_1;
$\frac{2N_0}{3} = N_0 e^{-\lambda t_1}$ ....(ii)
Dividing (ii) by (i), we get
$2 = e^{\lambda(t_2 - t_1)}$
$\Rightarrow \text{In}\, 2 = \lambda(t_2 - t_1)$
$\Rightarrow t_2 - t_1 = \text{In}\, 2 / \lambda$

Question217

Statement - 1 : A nucleus having energy E_1 decays by β^- emission to daughter nucleus having energy E_2, but the β^- rays are emitted with a continuous energy spectrum having end point energy $E_1 - E_2$.
Statement - 2 : To conserve energy and momentum in β^- decay at least three particles must take part in the transformation.
[2011 RS]

Options:

A. Statement-1 is correct but statement-2 is not correct.

B. Statement-1 and statement-2 both are correct and statement-2 is the correct explanation of statement-1.

C. Statement-1 is correct, statement-2 is correct and statement-2 is not the correct explanation of Statement-1

D. Statement-1 is incorrect, statement-2 is correct.

Answer: B

Solution:

Solution:
Statement-1: A nucleus having energy E_1 decays by β - emission to daughter nucleus having energy E_2 then β - rays are emitted with continuous energy spectrum with energy $E_1 - E_2$
Statement-2: For energy conservation and momentum conservation at least three particles, daughter nucleus, β particle and antineutrino are required.

Question218

The binding energy per nucleon for the parent nucleus is E_1 and that for the daughter nuclei is E_2. Then [2010]

Options:

A. $E_2 = 2E_1$

B. $E_1 > E_2$

C. $E_2 > E_1$

D. $E_1 = 2E_2$

Answer: C

Solution:

Solution:
In nuclear fission, the binding energy per nucleon of daughter nuclei is always greater than the parent nucleus.

Question219

The speed of daughter nuclei is [2010]

Options:

A. $c\frac{\Delta m}{M + \Delta m}$

B. $c\sqrt{\frac{2\Delta m}{M}}$

C. $c\sqrt{\frac{\Delta m}{M}}$

D. $c\sqrt{\frac{\Delta m}{M+\Delta m}}$

Answer: B

Solution:

Mass defect, $\Delta M = \left[(M+\Delta m) - \left(\frac{M}{2}+\frac{M}{2}\right)\right]$

$= [M + \Delta m - M] = \Delta m$

Energy released, $Q = \Delta M c^2 = \Delta mc^2$..... (i)

From the law of conservation of momentum

$(M+\Delta m) \times 0 = M\,2v_1 - \frac{M}{2} \times v_2$

$\Rightarrow v_1 = v_2$

Now, $Q = \frac{1}{2}\left(\frac{M}{2}\right)v_1{}^2 + \frac{1}{2}\left(\frac{M}{2}\right)v_2{}^2 - \frac{1}{2}$

$(M+\Delta m) \times (0)^2$

$= \frac{M}{2}v_1{}^2 (\because v_1 = v_2)$ ......(ii)

From equation (i) and (ii), we get

$\left(\frac{M}{2}\right)v_1{}^2 = \Delta mc^2$

$\Rightarrow v_1{}^2 = \frac{2\Delta mc^2}{M} \Rightarrow V_1 = c\sqrt{\frac{2\Delta m}{M}}$

Question220

A radioactive nucleus (initial mass number A and atomic number Z emits 3α - particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be [2010]

Options:

A. $\frac{A-Z-8}{Z-4}$

B. $\frac{A-Z-4}{Z-8}$

C. $\frac{A-Z-12}{Z-4}$

D. $\frac{A-Z-4}{Z-2}$

Answer: B

Solution:

When a radioactive nucleus emits 1α -particle, the mass number decreases by 4 units and atomic number decreases by 2 units. When a radioactive nucleus emits 1 positron the atomic number decreases by 1 unit but mass number remains constant.
∴ Mass number of final nucleus $= A - 12$
Atomic number of final nucleus $= Z - 8$
∴ Number of neutrons, $N_n = (A - 12) - (Z - 8) = A - Z - 4$
Number of protons, $N_p = Z - 8$
∴ Required ratio $= \frac{N_n}{N_p} = \frac{A - Z - 4}{Z - 8}$

Question221

The transition from the state n = 4 to n = 3 in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from :
[2009]

Options:

A. 3 → 2

B. 4 → 2

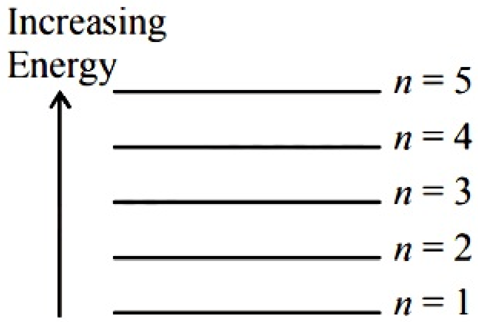
C. 5 → 4

D. 2 → 1

Answer: C

Solution:

Solution:
It is given that transition from the state n = 4 to n = 3 in a hydrogen like atom result in ultraviolet radiation. For infrared radiation $\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ should be less. The only option is 5 → 4.



Question222

Suppose an electron is attracted towards the origin by a force $\frac{k}{r}$ where ′k ' is a constant and ' r ' is the distance of the electron from the origin. By applying Bohr model to this system, the radius of the n^{th} orbital of the electron is found to be ' r_n ' and the kinetic energy of the electron to be

′T ′$_n$. Then which of the following is true?
[2008]

Options:

A. $T_n \propto \frac{1}{n^2}, r_n \propto n^2$

B. T_n independent of n, $r_n \propto n$

C. $T_n \propto \frac{1}{n}, r_n \propto n$

D. $T_n \propto \frac{1}{n^3}, r_n \propto n^2$

Answer: B

Solution:

Given,
Centripetal force $= \frac{k}{r}$
Then
$\frac{k}{r} = \frac{mv^2}{r}$
$\Rightarrow k = mv^2 \Rightarrow T\,n = \frac{1}{2}mv^2 = \frac{1}{2}k$
Tn is independent of n
Also,
Angular momentum, $L = \frac{nh}{2\pi}$
$\Rightarrow mvr_n = \frac{nh}{2\pi} (\because L = mvr)$
$\Rightarrow r_n = \frac{nh}{2\pi\sqrt{km}}$ $(\because m^2v^2 = km \text{ or } m\,v = \sqrt{km}$
Clearly, $r_n \propto n$

Question223

Statement-1: Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion and
Statement-2 : For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z.
[2008]

Options:

A. Statement-1 is false, Statement-2 is true

B. Statement-1 is true, Statement-2 is true; Statement-2 is a correct explanation for Statement-1

C. Statement-1 is true, Statement-2 is true; Statement-2 is not a correct explanation for Statement-1

D. Statement-1 is true, Statement-2 is false

Answer: D

Solution:

We know that energy is released when heavy nuclei undergo fission or light nuclei undergo fusion. Therefore statement (1) is correct.
The second statement is false because for heavy nuclei the binding energy per nucleon decreases with increasing Z and for light nuclei, B.E/nucleon increases with increasing Z.

Question224

Which of the following transitions in hydrogen atoms emit photons of highest frequency?
[2007]

Options:

A. n = 1 to n = 2

B. n = 2 to n = 6

C. n = 6 to n = 2

D. n = 2 to n = 1

Answer: D

Solution:

Solution:
We have to find the frequency of emitted photons.

For emission of photons electron should makes a transition from higher energy level to lower energy level. so, option (a) and (b) are incorrect.
Frequency of emitted photon is given by
$hv = -13.6\left(\frac{1}{{n_2}^2} - \frac{1}{{n_1}^2}\right)$
For transition from $n = 6$ to $n = 2$
$v_1 = \frac{-13.6}{h}\left(\frac{1}{6^2} - \frac{1}{2^2}\right) = \frac{2}{9} \times \left(\frac{13.6}{h}\right)$
For transition from $n = 2$ to $n = 1$,
$v_2 = \frac{-13.6}{h}\left(\frac{1}{2^2} - \frac{1}{1^2}\right) = \frac{3}{4} \times \left(\frac{13.6}{h}\right)$
$\∴v_{1}

Question225

Which of the following are the constituents of the nucleus?
[2007]

Options:

A. Electrons and protons

B. Neutrons and protons

C. Electrons and neutrons

D. Neutrons and positrons

Answer: B

Solution:

Solution:

Question226

If M_O is the mass of an oxygen isotope ${}_8O^{17}$, M_P and M_N are the masses of a proton and a neutron respectively, the nuclear binding energy of the isotope is
[2007]

Options:

A. $(M_O - 17M_N)c^2$

B. $(M_O - 8M_P)c^2$

C. $(M_O - 8M_P - 9M_N)c^2$

D. $M_O c^2$

Answer: C

Solution:

Number of protons in oxygen isotope, $Z = 8$
Number of neutrons $= 17 - 8 = 9$
Binding energy
$= [ZM_p + (A - Z)M_N - M]c^2$
$= [8M_p + (17 - 8)M_N - M]c^2$
$= [8M_p + 9M_N - M]c^2$
$= [8M_P + 9M_N - M_o]c^2$

Question227

The half-life period of a radio-active element X is same as the mean life time of another radio-active element Y. Initially they have the same number of atoms. Then
[2007]

Options:

A. X and Y decay at same rate always

B. X will decay faster than Y

C. Y will decay faster than X

D. X and Y have same decay rate initially

Answer: C

Solution:

Let λ_X and λ_Y be the decay constant of X and Y.
Half life of X, = average life of Y
$T_{1/2} = T_{av}$
$\Rightarrow \frac{0.693}{\lambda_X} = \frac{1}{\lambda_Y}$
$\Rightarrow \lambda_X = (0.693) . \lambda_Y$
$\therefore \lambda_X < \lambda_Y$
Now, the rate of decay is given by
$-\left(\frac{dN}{dt}\right)_x = \lambda_X N_0$
$-\left(\frac{dN}{dt}\right)_y = \lambda_y N_0$
As the rate of decay is directly proportional to decay constant, Y will decay faster than X.

Question228

An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to [2006]

Options:

A. v^2

B. $\frac{1}{m}$

C. $\frac{1}{v^2}$

D. $\frac{1}{Ze}$

Answer: B

Solution:

Work done to stop the α particle is equal to K.E.
$\therefore qV = \frac{1}{2}mv^2 \Rightarrow q \times \frac{K(Ze)}{r} = \frac{1}{2}mv^2$
$\Rightarrow r = \frac{2(2e)K(Ze)}{mv^2} = \frac{4KZe^2}{mv^2}$

$\Rightarrow r \propto \frac{1}{v^2}$ and $r \propto \frac{1}{m}$

Question229

When ${}_3Li^7$ nuclei are bombarded by protons, and the resultant nuclei are ${}_4Be^8$, the emitted particles will be [2006]

Options:

A. alpha particles

B. beta particles

C. gamma photons

D. neutrons

Answer: C

Solution:

Solution:

${}_3^7Li + {}_1^1p \rightarrow {}_4^8Be + {}_0^0\gamma$

We see that both proton number and mass number are equal in both sides, so emitted particle should be massless gamma photons.

Question230

If the binding energy per nucleon in ${}_3^7Li$ and ${}_2^4He$ nuclei are $5.60 MeV$ and $7.06 MeV$ respectively, then in the reaction $p + {}_3^7Li \rightarrow 2\,{}_2^4He$ energy of proton must be [2006]

Options:

A. 28.24 MeV

B. 17.28 MeV

C. 1.46 MeV

D. 39.2 MeV

Answer: B

Solution:

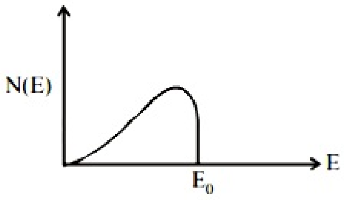
Given,
Binding energy per nucleon of ${}_3^7\mathrm{Li} = 5.60\mathrm{MeV}$
Binding energy per nucleon of ${}_2^4\mathrm{He} = 7.06\mathrm{MeV}$
Let E be the energy of proton, then
$E + 7 \times 5.6 = 2 \times [4 \times 7.06]$
$\Rightarrow E = 56.48 - 39.2 = 17.28\mathrm{MeV}$

Question231

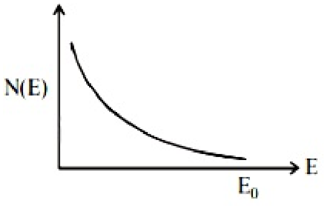
The energy spectrum of β-particles [number N(E) as a function of β-energy E] emitted from a radioactive source is [2006]

Options:

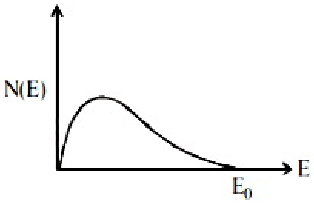
A.



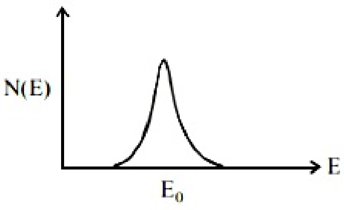
B.



C.



D.



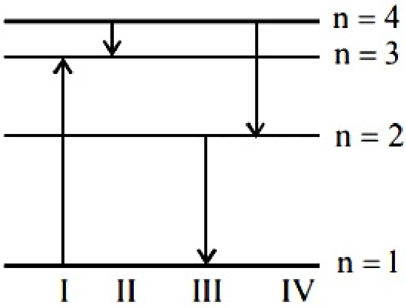
Answer: C

Solution:

Solution:
The range of energy of β-particles is from zero to some maximum value.

Question232

The diagram shows the energy levels for an electron in a certain atom. Which transition shown represents the emission of a photon with the most energy?



[2005]

Options:

A. IV

B. III

C. II

D. I

Answer: B

Solution:

Solution:
Eenrgy of radiation that corresponds to energy difference between two energy levels n_1 and n_2 is given as

$E = Rhc\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \therefore E \propto \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

E will be maximum for the transition for which $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ is maximum. Here n_2 is the higher energy level.

Clearly, $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ is maximum for the third transition, i.e., 2 → 1. I transition is showing the absorption of energy.

Question233

If radius of the ${}_{13}^{27}$Al nucleus is estimated to be 3.6 fermi then the radius of ${}_{52}^{125}$Te nucleus be nearly

[2005]

Options:

A. 8 fermi

B. 6 fermi

C. 5 fermi

D. 4 fermi

Answer: B

Solution:

Radius of a nucleus,
$R = R_0(A)^{1/3}$
Here, R_0 is a constant
A = atomic mass number
$\therefore \frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \left(\frac{27}{125}\right)^{1/3} = \frac{3}{5}$
$\Rightarrow R_2 = \frac{5}{3} \times 3.6 = 6$ fermi

Question234

A nuclear transformation is denoted by X (n, α)$_3{}^7$Li Which of the following is the nucleus of element X ? [2005]

Options:

A. $_5{}^{10}B$

B. $^{12}C_6$

C. $_4{}^{11}Be$

D. $_5{}^{9}B$

Answer: A

Solution:

$z^X + {}_0n^1 \rightarrow {}_3Li^7 + {}_2He^4$
Using conservation of mass number
$A + 1 = 4 + 7$
$\Rightarrow A = 10$
Using conservation of charge number
$Z + 0 = 2 + 3 \Rightarrow Z = 5$
It is boron $_5B^{10}$

Question235

Starting with a sample of pure ^{66}Cu, $\frac{7}{8}$ of it decays into Zn in 15 minutes. The corresponding half life is [2005]

Options:

A. 15 minutes

B. 10 minutes

C. $7\frac{1}{2}$ minutes

D. 5 minutes

Answer: D

Solution:

It is given that
$\frac{7}{8}$ of Cu decays in 15 minutes
$\therefore$Cu left undecayed is
$N = 1 - \frac{7}{8} = \frac{1}{8} = \left(\frac{1}{2}\right)^3$
$\therefore$ No. of half lifes $= 3$
$n = \frac{t}{T} \Rightarrow 3 = \frac{15}{T}$
$\Rightarrow T =$ half life period $= \frac{15}{3} = 5$ minutes

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Question236

The intensity of gamma radiation from a given source is I. On passing through 36mm of lead, it is reduced to $\frac{I}{8}$. The thickness of lead which will reduce the intensity to $\frac{I}{2}$ will be
[2005]

Options:

A. 9 mm

B. 6 mm

C. 12 mm

D. 18 mm

Answer: C

Solution:

Let intensity of gamma radiation from source be I_0.
Intensity $I = I_0 . e^{-\mu d}$
Where d is the thickness of lead.
Applying logarithm on both sides,
$-\mu d = \log\left(\frac{I}{I_0}\right)$
For $d = 36mm$, intensity $= \frac{I}{8}$

$-\mu \times 36 = \log\left(\frac{I / 8}{I}\right)$ ....(i)

For intensity $I / 2$, thickness $= d$

$-\mu \times d = \log\left(\frac{I / 2}{I}\right)$ ....(ii)

Dividing (i) by (ii),

$\frac{36}{d} = \frac{\log\left(\frac{1}{8}\right)}{\log\left(\frac{1}{2}\right)} = \frac{3\log\left(\frac{1}{2}\right)}{\log\left(\frac{1}{2}\right)} = 3$ or $d = \frac{36}{3} = 12mm$

Question237

An alpha -particle of energy $5MeV$ is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of [2004]

Options:

A. $10^{-12}cm$

B. $10^{-10}cm$

C. $10^{-14}cm$

D. $10^{-15}cm$

Answer: A

Solution:

Distance of closest approach

$r_0 = \frac{Ze(2e)}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$

Energy, $E = 5 \times 10^6 \times 1.6 \times 10^{-19}J$

$\therefore r_0 = \frac{9 \times 10^9 \times (92 \times 1.6 \times 10^{-19})(2 \times 1.6 \times 10^{-19})}{5 \times 10^6 \times 1.6 \times 10^{-19}}$

$\Rightarrow r_h = 5.2 \times 10^{-14}m = 5.3 \times 10^{-12}cm$

Question238

A nucleus disintegrated into two nuclear parts which have their velocities in the ratio of 2 : 1. The ratio of their nuclear sizes will be [2004]

Options:

A. $3^{1/2} : 1$

B. $1 : 2^{1/3}$

C. $2^{1/3} : 1$

D. $1 : 3^{1/2}$

Answer: B

Solution:

Given :
$\frac{v_1}{v_2} = \frac{2}{1}$
From conservation of momentum $m_1 v_1 = m_2 v_2$
$\Rightarrow \left(\frac{m_1}{m_2}\right) = \left(\frac{v_2}{v_1}\right) = \frac{1}{2}$
We know that mass of nucleus, $m \propto A$
Nuclear size $R \propto A^{1/3} \propto m^{1/3}$
$\frac{R_1}{R_2} = \left(\frac{m_1}{m_2}\right)^{1/3} \Rightarrow \frac{R_1{}^3}{R_2{}^3} = \frac{1}{2} \Rightarrow \left(\frac{R_1}{R_2}\right) = \left(\frac{1}{2}\right)^{1/3}$

Question239

The binding energy per nucleon of deuteron ($_1^2H$) and helium nucleus ($_2^4He$) is 1.1MeV and 7MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is [2004]

Options:

A. 23.6 MeV

B. 26.9 MeV

C. 13.9 MeV

D. 19.2 MeV

Answer: A

Solution:

Solution:
The chemical reaction of process is $2\,_1^2H \rightarrow {}_2^4He$
Binding energy of two deuterons, $4 \times 1.1 = 4.4$ MeV
Binding energy of helium nucleus $= 4 \times 7 = 28$ MeV
Energy released $= 28 - 4.4 = 23.6$ MeV

Question240

The wavelengths involved in the spectrum of deuterium ($_1^2D$) are slightly different from that of hydrogen spectrum, because [2003]

Options:

A. the size of the two nuclei are different

B. the nuclear forces are different in the two cases

C. the masses of the two nuclei are different

D. the attraction between the electron and the nucleus is differernt in the two cases

Answer: C

Solution:

Solution:
The wavelength of spectrum is given by
$\frac{1}{\lambda} = Rz^2\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)$
where $R = \frac{1.097 \times 10^7}{1 + \frac{m}{M}}$
where m = mass of electron
M = mass of nucleus.
Thus, wavelength involved in the spectrum of hudrogen like atom depends upon masses of nucleus. The mass number of hydrogen and deuterium is 1 and 2 respectively, so spectrum of deuterium will be different from hydrogen.

Question241

When a U^{238} nucleus originally at rest, decays by emitting an alpha particle having a speed ' u ', the recoil speed of the residual nucleus is [2003]

Options:

A. $\frac{4u}{238}$

B. $-\frac{4u}{234}$

C. $\frac{4u}{234}$

D. $-\frac{4u}{238}$

Answer: C

Solution:

Solution:
Mass of α particle, $m_\alpha = 4u$
Mass of nucleus after fission, $m_n = 234u$ From conservation of linear momentum we have
$238 \times 0 = 4u + 234v$
$\therefore v = -\frac{4}{234}u$
$\therefore$ Speed $= \left|\vec{v}\right| = \frac{4}{234}u$

Question242

In the nuclear fusion reaction
${}_1^2H + {}_1^3H \rightarrow {}_2^4He + n$
given that the repulsive potential energy between the two nuclei is $\sim 7.7 \times 10^{-14} J$, the temperature at which the gases must be heated to initiate the reaction is nearly [Boltzmann's Constant $k = 1.38 \times 10^{-23} J / K$]
[2003]

Options:

A. $10^7 K$

B. $10^5 K$

C. $10^3 K$

D. $10^9 K$

Answer: D

Solution:

Solution:
The average kinetic energy per molecule at temperature T is
$= \frac{3}{2}kT$
Where k = Boltzmann's constant
This kinetic energy should be able to provide the repulsive potential energy
$\therefore \frac{3}{2}kT = 7.7 \times 10^{-14}$
$\Rightarrow T = \frac{2 \times 7.7 \times 10^{-14}}{3 \times 1.38 \times 10^{-23}} = 3.7 \times 10^9 K$

Question243

Which of the following cannot be emitted by radioactive substances during their decay?
[2003]

Options:

A. Protons

B. Neutrinoes

C. Helium nuclei

D. Electrons

Answer: A

Solution:

The radioactive substances emit α -particles (Helium nucleus), β-particles (electrons) and neutrinoes. Protons cannot be emitted by radioactive substances during their decay.

Question244

A nucleus with Z = 92 emits the following in a sequence: $\alpha, \beta^{-}, \beta^{-}\alpha, \alpha, \alpha, \alpha, \alpha, \beta^{-}, \beta^{-}, \alpha, \beta^{+}, \beta^{+}, \alpha$ Then Z of the resulting nucleus is [2003]

Options:

A. 76

B. 78

C. 82

D. 74

Answer: B

Solution:

Solution:
The number of α -particles released = 8
Decrease in atomic number $= 8 \times 2 = 16$
The number of μ^{-} -particles released = 4
Increase in atomic number $= 4 \times 1 = 4$
Also the number of β^{+} particles released is 2, which should decrease the atomic number by 2 .
Therefore the final atomic number of resulting nucleus
$= Z - 16 + 4 - 2 = Z - 14$
$= 92 - 14 = 78$

Question245

A radioactive sample at any instant has its disintegration rate 5000 disintegrations per minute. After 5 minutes, the rate is 1250 disintegrations per minute. Then, the decay constant (per minute) is [2003]

Options:

A. 0.4 ln 2

B. 0.2 ln 2

C. 0.1 ln 2

D. 0.8 ln 2

Answer: A

Solution:

Initial activity, A_o = 5000 disintegration per minute
Activity after 5 min, A = 1250 disintegration per minute
$A = A_o e^{-\lambda t}$
$\Rightarrow e^{-\lambda t} = \frac{A_o}{A}$
$\Rightarrow \lambda = \frac{1}{t}\log_e\frac{A_o}{A} = \frac{1}{5}\log_e\frac{5000}{1250}$
$= \frac{2}{5}\log_e 2 = 0.4\log_e 2$

Question246

If 13.6 eV energy is required to ionize the hydrogen atom, then the energy required to remove an electron from n = 2 is [2002]

Options:

A. 10.2 eV

B. 0 eV

C. 3.4 eV

D. 6.8 eV

Answer: C

Solution:

Solution:
The energy required to remove the electron from the n^{th} orbit of hydrogen is given by
$E_n = \frac{13.6}{n^2}$ eV / atom
For $n = 2$, $E_n = \frac{13.6}{4} = 3.4eV$
Therefore the energy required to remove electron from $n = 2$ is $+3.4eV$

Question247

At a specific instant emission of radioactive compound is deflected in a magnetic field. The compound can emit
(i) electrons
(ii) protons
(iii) He^{2+}
(iv) neutrons
The emission at instant can be
[2002]

Options:

A. i, ii, iii

B. i, ii, iii, iv

C. iv

D. ii, iii

Answer: A

Solution:

Solution:
Charged particles are deflected in magnetic field.
Electrons, protons and He^{2+} all are charged species. Hence, correct option is (a).

Question248

If N_0 is the original mass of the substance of half-life period $t_{1/2} = 5$ years, then the amount of substance left after 15 years is [2002]

Options:

A. $N_0 / 8$

B. $N_0 / 16$

C. $N_0 / 2$

D. $N_0 / 4$

Answer: A

Solution:

After every half-life, the mass of the substance reduces to half its initial value.

$$N_0 \xrightarrow{5\text{years}} \frac{N_0}{2} \xrightarrow{5\text{years}} \frac{N_0/2}{2} = \frac{N_0}{4} \xrightarrow{5\text{years}} \frac{N_0/4}{2} = \frac{N_0}{8}$$
