JEE ADVANCED-PART TEST-22 (PHYSICS)

SOLUTION OF MOCK TEST

CONDUCTED ON DOUBTNUT APP

Q-1 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

A very large metal plate carries a charge of $Q = -1C$. The work function for the metal is $\phi = 3eV$ The plate is illuminated by a 60 watt light source with a wavelength λ of $330nm$. How long does it take to completely discharge the plate? (Assume that every efficient photon ejects electron which is instantly removed from the sheet surface. (All photons ejected from light source fall normally on the metal plate) $(h = 6.6 \times 10^{-34} m^2 kg / s)$

(A) 0.005 s

(B) 0.025 s

(C) 0.0625 s

(D) 0.01

Correct Option : C

SOLUTION

The energy per photon is

$$E_\lambda = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} m^2 kg / s \times 3 \times 10^8 m / s}{3.3 \times 10^{-7} m} 6 \times 10^{-19} J$$

The time is to discharge the plate is given by total number of electrons divided by the rate of photons

$$t = Q / e \times \frac{E_\lambda}{P} = \frac{6 \times 10^{-19} J}{1.6 \times 10^{-19} \times 60 J / s} = 0.0625 s$$

Q-2 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

Consider the following statements: (i) Nuclear fission is normally followed by emission of β-particles. (ii) Emission of α-particle is normally followed by emission of γ rays. (iii) In carbon-carbon cycle of fusion reaction which powers the large starts, two carbon nuclei combine to form a magnesium nucleus:

The correct order of True/False in above statements is

(A) TTT

(B) TTF

(C) FTT

(D) TFT

Correct Option : B

SOLUTION

(i) Nuclear fission results in fragments whose neutron/proton ratio is higher than the required value (N/P ratios is greater for heavier nuclei). To reduce the N/P ratio these fragments undergo β^- decays in which a neutron is converted into a proton.

(ii) Some of the energy generated in α-emission goes into nuclear excitation. the excited nucleus returns to ground state by γ-emission.

(iii) in carbon -carbon cycle .^{12}C nucleus acts just as a catalust. the net result is fusion of four protons into a healium nucleus.

Q-3 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

A particle of mass \'m\' is projected from ground with velocity u making angle θ with the vertical. The de-Broglie wave length of the particle at the highest point is:

(A) ∞

(B) $\dfrac{h}{mu\sin\theta}$

(C) $\dfrac{h}{mu\cos\theta}$

(D) $\dfrac{h}{mu}$

Correct Option : B

SOLUTION

(C) velocity at highest point $= u \sin \theta$.

$\therefore \lambda_d = \dfrac{h}{mu \sin \theta}$ (Since θ is angle between velocity and vertical)

Q-4 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

Light of wavelength $400 nm$ is incident continuously on a Cesium ball. (work function $1.9 eV$). The maximum potential to which the ball will be charged is

(A) 3.1V

(B) 1.2 V

(C) zero

(D) infinite

Correct Option : B

SOLUTION

(B) $eV_s = \frac{hc}{\lambda} - \phi = \frac{1240(nm)eV}{400(nm)} - 1.9eV = 1.2eV$

$\Rightarrow V_s = 1.2V$

$\therefore$ The cesuim ball can be charged to a maximum potential of 1.2 V

Q-5 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

In a photoelectric experiment, with light of wavelength λ, the fastest election has speed v. If the exciting wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will become

(A) $v\sqrt{\frac{3}{4}}$

(B) $v\sqrt{\frac{4}{3}}$

(C) less than $v\sqrt{\frac{3}{4}}$

(D) greater then $v\sqrt{\frac{4}{3}}$

Correct Option : D

SOLUTION

(D) $\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi$

$\frac{1}{2}mv'^2 = \frac{hc}{(3\lambda/4)} - \phi = \frac{4hc}{3\lambda} - \phi$

Clearly $v' > \sqrt{\frac{4}{3}}v$

Q-6 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

The radionuclide $.^{238}U$ decays by emitting an alpha particle.

$.^{238}U \rightarrow .^{234}Th + .^{4}He$ The atomic masses of the three isotopes are

$.^{238} \quad U238.05079amu$

$.^{234}U \quad 234.040363amu$

$.^{4}He \quad 4.00260amu$ What is the maximum kinetic energy of the emitted alpha particle. Express your answer in Joule. (

$1 amu = 1.67 \times 10^{-27} kg$)

(A) $6.8 \times 10^{-14} J$

(B) $6.8 \times 10^{-13} J$

(C) $4.3 \times 10^{-14} J$

(D) $4.3 \times 10^{-13} J$

Correct Option : B

SOLUTION

Mass defect =(238.05079-234.04363-4.00260) u=$4.56 \times 10^{-3} u$

$mc^2 = 7.57 \times 10^{-30} \times 9 \times 10^{16} = 6.8 \times 10^{-13} J$

Q-7 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

The energy that should be added to an electron, to reduce its de-Broglie wavelength from $2 \times 10^{-9} m$ to $0.5 \times 10^{-9} m$ will be:

(A) 1.1 MeV

(B) 0.56 MeV

(C) 0.56KeV

(D) 5.6 eV

Correct Option : D

SOLUTION

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$$

$$\therefore E = \frac{h^2}{2m\lambda^2}$$

$$\Delta E = \frac{h^2}{2m}\left(\frac{1}{\lambda_1^2} - \frac{1}{\lambda_2^2}\right)$$

Put $\lambda_1 = \frac{0}{5} \times 10^{-9} m$

& $\lambda_2 = 2 \times 10^{-9} m$ and solve.

Q-8 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

X-rays of high penetrating power are called hard X-ray. Hard X-rays have energy of the order of $10^5 eV$. The minimum potential difference through which the electrons should be accelerated in an X-ray tube to obtain X-ray of energy $10^5 eV$ is:

(A) $2 \times 10^5 V$

(B) 50 kV

(C) 40 kV

(D) $10^5 V$

Correct Option : D

SOLUTION

If electrons are accelerated through a potential difference V, the maximum energy of emitted photon could be

$$E_{\max} = eV \therefore 10^5 eV = eV$$

$$\Rightarrow V = 10^5 V.$$

Q-9 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

The voltage applied to an X-ray tube is 18 kV. The maximum mass of phton emitted by the X-ray tube will be

(A) $2 \times 10^{-13} kg$

(B) $3.2 \times 10^{-36} kg$

(C) $3.2 \times 10^{-32} kg$

(D) $9.1 \times 10^{-31} kg$

Correct Option : C

SOLUTION

Energy of photon is given by mc^2 now the maximum energy of photon is equal to the maximum energy of electorn =e V

hence,

$$mc^2 = ev \Rightarrow m = \frac{eV}{c^2} = \frac{1.6 \times 10^{-19} \times 18 \times 10^3}{\left(3 \times 10^8\right)^2} = 3.2 \times 10^{-32}$$

Q-10 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

STATEMENT1: The frequency and intensity of a light source are both doubled then saturation photocurrent changes significantly.

STATEMENT2: When frequency and intensity of a light source both are doubled then kinetic energy of emitted electrons is doubled.

(A) Statement-1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement-2 is True, Statement-2 is NOT a correct explanation for Statement-1

(C) Statement-1 is False, Statement-2 is True

(D) Statement-1 is False, Statement-2 is False

Correct Option : D

SOLUTION

The number of photons incident per unit time remains same hence saturation photo current remains same. If frequency is doubled then kinetic energy of photo electrons is more than doubled.

Q-11 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

An isolated nucleus which was initially at rest, disintegrates into two nuclei due to internal nuclear forces and noγ rays are produced. If the ratio of their kinetic energy is found to be

(A) Ratio of their de-broglie wavelength is $\frac{\sqrt{64}}{\sqrt{27}}$ respectively

(B) Ratio of their speed is 64/27 respectively

(C) Ratio of their nuclear radius is 5/4 respectively

(D) None of these

Correct Option : B

SOLUTION

$P_1 = P_2 = P$

$m_1 v_1 = m_2 v_2$

$$\left(\frac{P^2}{2m_1}\right) / \left(\frac{P^2}{2m_2}\right) = \frac{64}{27}$$

$$\frac{m_2}{m_1} - \frac{64}{27} = \frac{v_1}{v_2}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{h / P_1}{h / P_2} = 1 : 1$$

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \frac{3}{4}$$

n a sample of radioactive nuclide

(A) a nucleus emits, α, β radiations simultaneously.

(B) only α, β can be emitted simultaneously by a nucleus.

(C) α, β, γ may be obtained simultaneously from the sample

(D) all the three α, β, γ one after other will obtained from a nucleus

Correct Option : C

SOLUTION

Type of particle emittion cannot be generalised for all reaction.

Hence α, β, γ particles may be emitted simultaneously.

In a radioactive reactor, radionuclide X are being injected at a rate of r atoms/sec which decay to a stable daughter nuclide Y according to equation.

$X \xrightarrow{\lambda} Y + \Delta E$

The energy released in each decay process is transformed to electricity and used to light up a bulb. If the process starts at t = 0 then :(At t = 0 The number of radionuclide X = 0)

(A) Brightness of bulb increases with time in the beginning and then becomes constatnt

(B)) Brightness of bulb decreases with time in the beginning and then becomes constatnt

(C) Brightness first increases then decreases later

(D) Brightness first decreases then increases later

Correct Option : A

SOLUTION

The rate of accumulation of nuclei of X in the reactor can be given as

$$\frac{dN_X}{dt} = r - \lambda N_x$$

$$\Rightarrow N_x = \frac{r}{\lambda}\left(1 - e^{-\lambda t}\right)$$

Thus amount of N_X continuously increases with time hence brightness of bulb will continuously increases.

Q-14 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

Radius of a nucleus is given by the relation $R = R_0 A^{1/3}$ where $R_0 = 1.3 \times 10^{-15} m$ and A is mass number. For a nucleon inside a nucleus, de-Broglie wavelength is given by diameter of the nucleus. Average kinetic energy of a nucleon in the Te^{128} nucleus based on above information will be :

(A) 4.7 MeV

(B) 10 MeV

(C) 2 MeV

(D) 12 MeV

Correct Option : A

SOLUTION

$$\lambda = 2R = 2R_0 A^{1/3}$$

$$P = \frac{h}{\lambda} \Rightarrow E = \frac{P^2}{2m} = \frac{h^2}{2m\left(4R_0^2 A^{2/3}\right)}$$

$$E = \frac{\left(6.62 \times 10^{-34}\right)^2}{2 \times 1.67 \times 10^{-27} \times 4\left(1.3 \times 10^{-15}\right)^2 (128)^{2/3}} \text{ joule}$$

=4.72 MeV.

Q-15 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

Three samples of a radioactive substance have activity in a ratio 2 : 5 : 7 , then after two half lives the ratio of their activities will be:

(A) 0.0868865740740741

(B) 0.0438078703703704

(C) 0.295162037037037

(D) data insufficient

Correct Option : A

SOLUTION

Activity after time t

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

$A = \lambda A_i$

$A = \lambda$ (initial activity)

$A \propto$ initial activity

Q-16 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

The only source of energy in a particular star is the fusion reaction given by -

$3 ._2 He^4 \rightarrow ._6 C^{12}$+energy

Masses of $._2 He^4$ and $._6 C^{12}$ are given

$\left(m ._2 He^4\right) = 4.0025u, m\left(._6 C^{12}\right) = 12.0000u$

Speed of light in vaccume is $3 \times 10^8 m/s$. power output of star is 4.5×10^{27} watt. The rate at which the star burns helium is

(A) $8 \times 10^{12} kg/s$

(B) $4 \times 10^{13} kg/s$

(C) $8 \times 10^{13} kg/s$

(D) $6 \times 10^{13} kg/s$

Correct Option : C

SOLUTION

Fraction of mass converted in energy

$$\frac{3 \times 4.0025 - 12.0000}{3 \times 4.0025} = \frac{0.0075}{12} - \frac{\text{Rate of loss of mass}}{\text{Rate of burning}}$$

$$\text{Rate of burnig} = \frac{12}{75 \times 10^{-4}} \times \frac{\text{Power output}}{C^2}$$

$$= \frac{12}{775 \times 9 \times 10^{12}} = \frac{54}{9 \times 75} \times 10^{15} = \frac{2}{25} \times 10^{15} = 8 \times 10^{13} kg$$

Q-17 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

The decay constant of a radioactive substance is $0.173 \text{ (years)}^{-1}$.

Therefore:

(A) Nearly 63% of the radioactive substance will decay in (1/0.173) year.

(B) half life of the radio active substance is (1/0.173) year.

(C) one-fourth of the radioactive substance will be left after nearly 8 years.

(D) one-fourth of the radioactive substance will be left after nearly 6 years.

Correct Option : A

SOLUTION

Given $\lambda = 0.173$

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{0.173} \cong 4$$

Also for t 1/0.173 year

Remaining nuclei $N = N_0 e^{-1} = 0.37 N_0$

Decay nuclie=$N_0 - N = 0.63 N_0$

Q-18 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

A fusion reaction consists of combining four protons into an αparticle. The mass of αparticle is 4.002603u and that of proton is 1.007825u, mass of electron is 0.00054466u.

(A) the equation $4p_1^1 \to He_2^4$ does not satisfy conservation of charge

(B) the correct reaction equation may be

$4p_1^1 \rightarrow He_2^4 + 2\beta^+ + 2\upsilon$ where β^+ is positron and υ is the neutrino (zero rest mass and uhcharged)

(C) the energy equivalent of the mass defect is 25.7 MeV

(D)

Correct Option : A

SOLUTION

Mass defect $\Delta m = 4m_H - m_{He} - 2m_e$

$$Q = 0.02608 \times 932 \frac{MeV}{u} = 25.7MeV$$

Q-19 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

When a hydrogen atom is excited from ground state to first excited state then

(A) its kinetic energy increases by 10.2 eV

(B) its kinetic energy decreases by 10.2 eV

(C) its potential energy increases by 20.4 eV

(D) its angular momentum increases by

$1.05 \times 10^{-34} J - s$

Correct Option : B

SOLUTION

In ground state n=1 and for first excited state n=2

$$KE = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{2r}(z=1) = \frac{14.4\times10^{-10}}{2r}eV\left(\because{}'r = 0.53n^2A^0(z =\right.$$

$$(KE)_1 = \frac{14.4\times10^{-10}}{2\times0.53\times10^{-10}}eV = 13.58eV \text{ and}$$

$$(KE)_2 = \frac{14.4\times10^{-10}}{2\times0.53\times10^{-10}\times4}ev = 3.39ev$$

$\therefore$ Ke decreasess by 10.2 ev

$\therefore$ PE increases by =Excitation energy + Loss in kinetic energy

=10.2+10.2=20.4 ev

Now angular momentum, $L = mvr = \frac{nh}{2\pi}$

$$\Rightarrow L_2 - L_1 = \frac{h}{2\pi} = \frac{6.6 \times 10^{-34}}{6.28} = 1.05 \times 10^{-34} J - \sec$$

Q-20 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

X-ray from a tube with a target A of atomic number Z shows strong K_α lines for target A and two weak K_α lines forimpurities. The wavelength of K_α lines is λ_0 for target A and λ_1 and λ_2 for two impurities respectively. $\frac{\lambda_0}{\lambda_1} = 4$ and $\frac{\lambda_0}{\lambda_2} = \frac{1}{4}$. The screening constant of K_α lines is unity. Select the correct alternative(s) :

(A) The atomic number of first impurity is 2Z-1

(B) The atomic number of first impurity is 2Z+1

(C) The atomic number of first impurity is $\frac{Z+1}{2}$

(D) The atomic number of second impurity is Z/2+1

Correct Option : A

SOLUTION

$$\frac{\lambda_0}{\lambda_1} = 4 \implies \frac{(Z_1-1)^2}{(Z-1)^2} = 4 \implies Z_1 = 2Z - 1$$

$$\frac{\lambda_0}{\lambda_2} = \frac{1}{4} \implies \frac{(Z_2-1)^2}{(Z-1)^2} = 4 \implies Z_2 = \frac{Z+1}{2}$$

Q-21 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

The electron in hydrogen atom makes a transition $n_1 \rightarrow n_2$ where n_1 and n_2 are the principal quantum number of two states. Assuming the Bohr model to be valid, the time period of the electron in the initial state is eight times that in the final state. The possible value of n_1 and n_2 are:

(A) $n_1 = 2$ And $n_2 = 1$

(B) $n_1 = 8$ and $n_2 = 2$

(C) $n_1 = 8$ And $n_2 = 1$

(D) $n_1 = 6$ and $n_2 = 3$

Correct Option : A

SOLUTION

Time period $T_n = \frac{2\pi r_n}{V_n}$

$T \propto \frac{n^2}{1/n}$

i.e. $T \propto n^3$

$T_{n_1} = 8T_{n_2}$

$n_1 = 2n_2$

Hence $n_1 = 2n_2$

Choice (b) and (c) are wrong.

Q-22 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

The correct statement is/are

(A) Density of nucleus is independent of mass number (A)

(B) Radius of nucleus increases with mass number (A)

(C) Mass of nucleus is directly proportional to mass number(A).

(D) Density of nucleus is directly proportional to mass number.

Correct Option : A

SOLUTION

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

Radius of nucleus $R \propto A^{1/3}$

So choice (b) is correct.

Density =Mass/Volume $= \dfrac{A \times 1.67 \times 10^{-27}}{\frac{4}{3}\pi R_0^3 A}$

Density $\propto A^0$

i.e. Density is independent of mass number.

So, choice (a),(b) and (c) are correct and choice (d) is wrong.

Q-23 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

The correct statements among the following are:(Consider only normal incidence)

(A) Pressure exerted by photons for perfectly reflecting surface is $\frac{2I}{C}$

(B) Force exerted by photons on a perfectely reflecting surface is $\frac{2P}{C}$

(C) Impulse applied by photon on a perfectely reflecting surface is $\frac{2E}{C}$

(D) Force exerted by photons on a perfectly reflecting surface is $\frac{P}{C}$

Correct Option : A

SOLUTION

Pressure$=\frac{I}{C}(1+r)$ where I is the intensity

$F=\frac{P}{C}$ (1+r) where P is the power

Impulse I=E/C (1+r)

where E is the energy

r is the reflection coefficient.

and r=1 for perfectely reflecting surface.

Choice (d) is wrong.

Q-24 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

An electron revolves in first orbit in H atom, then :

(A) Current associated due to orbital motion of electron is

1.06 m A.

(B) Magnetic field at the centre of nucleus due to orbital motion of electron is 12.5 Tesla.

(C) First excitation energy of H atom is 10.2 eV.

(D) Current associated due to orbital motion of electron is 2.06 m A.

Correct Option : A

SOLUTION

$$I = \frac{1.96z^2}{n^3} mA$$

For H atom z=1 and first orbit n=1

I=1.06 mA. So choice (a) is correct

Magnetic field $B = \frac{12.5Z^3}{n^5}$ Tesla

B=12.5 Tesla. So, choice (b) is correct

$= 13.6 \times \frac{3}{4} = 10.2eV$. so, choice (c) id correct.

Q-25 - JEE ADVANCED-PART TEST-22 (PHYSICS)-PHYSICS

A parallel beam of uniform, monochromatic light of wavelength 6600 has an intensity of $900Wm^{-2}$. The number of photons in $1mm^3$ of this radiation are 1×10^X then find out value of X.

(A) 2

(B) 4

(C) 6

(D) 8

Correct Option : B

SOLUTION

Energy incident in $1m^2$ in 1 sec.

E=900 J

$$\frac{hc}{\lambda}n \times 1 \times 3 \times 10^8 = 900$$

$n = 10^{13}$ photons / m^3

$n = 10^4$ photons/mm^3