QB365 Question Bank Software

12th Physics Case study Questions Nuclei For - 2024

12th Standard

Physics

SECTION 1 2 x 4 = 8

1) A heavy nucleus breaks into comparatively lighter nuclei which are more stable compared to the original heavy nucleus. When a heavy nucleus like uranium is bombarded by slow moving neutrons, it splits into two parts releasing large amount of energy. The typical fission reaction of ${}_{92}\mathrm{U}^{235}$.

$${}_{92}\mathrm{U}^{235}+{}_{0}n^{1}\rightarrow{}_{56}\mathrm{Ba}^{141}+{}_{36}\mathrm{Kr}^{92}+3{}_{0}n^{1}+200\mathrm{MeV}$$

The fission of ${}_{92}\mathrm{U}^{235}$approximately released 200 MeV of energy.

(i) If 200 MeV energy is released in the fission of a single nucleus of ${}_{92}^{235}\mathrm{U}$,the fissions which are required to produce a power of 1kW is

(a) 3.125×10^{13} **(b) 1.52×10^{6}** **(c) 3.125×10^{12}** **(d) 3.125×10^{14}**

(ii) The release in energy in nuclear fission is consistent with the fact that uranium has

(a) more mass per nucleon than either ofthe two fragments

(b) more mass per nucleon as the two fragment

(c) exactly the same mass per nucleon as the two fragments

(d) less mass per nucleon than either of two fragments.

(iii) When ${}_{92}\mathrm{U}^{235}$undergoes fission, about 0.1% of the original mass is converted into energy. The energy released when 1 kg of ${}_{92}\mathrm{U}^{235}$undergoes fission is

(a) 9×10^{11}J **(b) 9×10^{13}J** **(c) 9×10^{15}J** **(d) 9×10^{18}J**

(iv) A nuclear fission is said to be critical when multiplication factor or K

(a) K= 1 **(b) K > 1** **(c) K< 1** **(d) K=0**

(v) Einstein's mass-energy conversion relation E = mc^2 is illustrated by

(a) nuclear fission **(b) β-decay** **(c) rocket propulsion** **(d) steam engine**

Answer : **(i) (a)** : Let the number of fissions per second be n. Energy released per second

$$=n\times 200\mathrm{MeV}=n\times 200\times 1.6\times 10^{-13}\ \mathrm{J}$$

Energy required per second = power x time

$$=1\ \mathrm{kW}\times 1\ \mathrm{s}=1000\ \mathrm{J}$$

$$\therefore \quad n\times 200\times 1.6\times 10^{-13}=1000$$

$$\text{or} \quad n=\frac{1000}{3.2\times 10^{-11}}=\frac{10}{3.2}\times 10^{13}=3.125\times 10^{13}$$

(ii) (a)

(iii) (b): As only 0.1% of the original mass is converted into energy, hence out of 1 kg mass 1 g is converted into energy.

$\therefore$ Energy released during fission, $E=\Delta mc^2$

$$=1\ \mathrm{g}\times\left(3\times 10^{8}\ \mathrm{m\ s}^{-1}\right)^{2}=10^{-3}\times 9\times 10^{16}\ \mathrm{J}=9\times 10^{13}\ \mathrm{J}$$

(iv) (a)

(v) (a)

2) When subatomic particles undergo reactions, energy is conserved, but mass is not necessarily conserved.However, a particle's mass "contributes" to its total energy, in accordance with Einstein's famous equation, E = mc^2, In this equation, E denotes the energy carried by a particle because of its mass. The particle can also have additional energy due to its motion and its interactions with other particles. Consider a neutron at rest and well separated from other particles. It decays into a proton, an electron and an undetected third particle as given here: Neutron $\longrightarrow$ proton + electron + ???

The given table summarizes some data from a single neutron decay. Electron volt is a unit of energy. Column 2 shows the rest mass of the particle times the speed of light squared.

Particle	Mass x c^2 (MeV)	Kinetic energy (MeV)
Neutron	940.97	0.00
Proton	939.67	0.01
Electron	0.51	0.39

(i) From the given table, which properties of the undetected third particle can be calculate?

(a) Total energy, but not kinetic energy **(b) Kinetic energy, but not total energy**

(c) Both total energy and kinetic energy **(d) Neither total energy nor kinetic energy**

(ii) Assuming the table contains no major errors, what can we conclude about the (mass x c^2) of the undetected third particle?

(a) It is 0.79 MeV

(b) It is 0.39 MeV

(c) It is less than or equal to 0.79 MeV; but we cannot be more precise.

(d) It is less than or equal to 0.40 MeV; but we cannot be more precise.

(iii) Could this reaction occur?

Proton $\longrightarrow$ neutron + other particles

(a) Yes, if the other particles have much more kinetic energy than mass energy.

(b) Yes, but only if the proton has potential energy (due to interactions with other particles).

(c) No, because a neutron is more massive than a proton.

(d) No, because a proton is positively charged while a neutron is electrically neutral.

(iv) How much mass has to be converted into energy to produce electric power of 500 MW for one hour?

(a) 2 x 10^{-5} kg(b) 1 x 10^{-5} kg(c) 3 X 10^{-5} kg(d) 4 x 10^{-5} kg

(v) The equivalent energy of 1 g of substance is

(a) 9 x 10^{13}J **(b) 6 x 10^{12}J** **(c) 3 x 10^{13}J** **(d) 6 x 10^{13}J**

Answer : (i) (a) : As just shown, energy conservation allows us to calculate the third particle's total energy.But we do not know what percentage of that total is mass energy.

(ii) (d): According to the passage, subatomic reactions do not conserve mass. So, we cannot find the third particle's mass by setting $m_{neutron}$equal to $m_{proton}+m_{electron}+m_{thirdparticle}$

The neutron has energy 940.97 MeV. The proton has energy 939.67 MeV + 0.01 MeV = 939.69 MeV. The electron has energy 0.51 MeV + 0.39 MeV = 0.90 MeV.

Therefore, the third particle has energy

$$E_{\text{third particle}} = E_{\text{neutron}} - E_{\text{proton}} - \mathrm{E}_{\text{Electron}}$$

= 940.97 - 939.67 - 0.90 = 0.40 MeV

We just found the third particle's total energy, the sum of its mass energy and kinetic energy. Without more information, we cannot figure out how much of that energy is mass energy.

(iii) (b)

(iv) (a): Here, P = 500 MW = 5 x 10^8 W,

t = 1 h = 3600 s

Energy produced, E = P x t = 5 x 10^8 x 3600

= 18 x 10^{11} J

$$\text{As } E = \Delta mc^2$$

$$\therefore \quad \Delta m = \frac{E}{c^2} = \frac{18\times10^{11}}{(3\times10^8)^2} = \frac{18\times10^{11}}{9\times10^{16}} = 2\times10^{-5}\text{ kg}$$

(v) (a): Using, E = mc^2

Here, $m = 1\text{ g} = 1\times10^{-3}\text{ kg}, c = 3\times10^8\text{ m s}^{-1}$

$$\therefore E = 10^{-3}\times9\times10^{16} = 9\times10^{13}\text{ J}$$