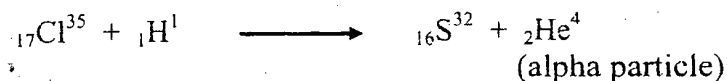


19.16 PROBLEMS:

Problem # 19.1

When the chlorine atom of mass numbers 35 and charge number 17, is bombarded by Proton, the resulting disintegrates, emitting an α -particle. Write the equation representing the reaction.



Problem # 19.2

The half life of Radon is 3.80 days. What would be its decay constant?

Data:

$$T_{\frac{1}{2}} = 3.80 \text{ days}$$

$$T_{\frac{1}{2}} = 328320 \text{ sec}$$

$$\lambda = ?$$

Solution:

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

$$\lambda = \frac{0.693}{T_{\frac{1}{2}}}$$

$$\lambda = \frac{0.693}{328320}$$

$$\lambda = 2.1 \times 10^{-6} \text{ S}^{-1}$$

Problem # 19.3

The atomic weight of Bromine is 79.938u and it is composed of two isotopes of mass 78.943u and 80.942 u compute the percentage of each isotopes.

Solution:

Let the part of the 1st isotope be X and that of 2nd isotope be (1- X).

$$78.943 X + (1- X) 80.942 = 79.938$$

$$78.943 x + 80.942 - 80.942 X = 79.938$$

$$+ 1.999x = + 1.004$$

$$X = \frac{1.004}{1.999}$$

$$X = 0.502$$

$$\begin{aligned} \text{Percentage of 1}^{\text{st}} \text{ isotope} &= 0.502 \times 100 \\ &= 50.2\% \end{aligned}$$

$$\begin{aligned} \text{Percentage of 2}^{\text{nd}} \text{ isotope} &= 100 - 50.2 \\ &= 49.8\% \end{aligned}$$

Problem # 19.4

The half of ${}_{104}\text{Po}^{210}$ is 140 days. By what percent does its activity will decrease per week?

Data:

$$T_{\frac{1}{2}} = 140 \text{ days}$$

$$t = 1 \text{ week}$$

Percentage decrease in activity per week = ?

Solution:

$$T_{\frac{1}{2}} = \frac{140}{7} = 20 \text{ week}$$

let the initial activity be A.

$$A = \lambda N_0$$

And activity after one week be A'

$$A' = \lambda N$$

$$\begin{aligned} \text{Describe is activity per week} &= A - A' \\ &= \lambda N_0 - \lambda N \\ &= \lambda (N_0 - N) \end{aligned} \quad \text{--- (1)}$$

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

$$\lambda = \frac{0.693}{T_{\frac{1}{2}}}$$

$$\lambda = \frac{0.693}{20}$$

$$\lambda = 0.03465 \text{ week}^{-1}$$

From the law of radio activity decay

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

$$N = N_0 e^{-0.03465 \times 1}$$

$$N = 0.966 N_0$$

$$\begin{aligned} \text{eq. (1)} = \text{Decrease in activity per week} &= \lambda (N_0 - 0.966 N_0) \\ &= \lambda N_0 (1 - 0.966) \\ &= 0.034 \lambda N_0 \end{aligned}$$

$$\begin{aligned} \text{Percentage decrease in activity per week} &= \frac{0.034 \lambda N_0}{A} \times 100 \\ &= \frac{0.034 \lambda N_0}{\lambda N_0} \times 100 \\ &= 3.4 \% \end{aligned}$$

Problem # 19.5

If a neutron would be entirely converted into energy, how much energy would be produced? Express your answer in joules as well as electron volts.

Data:

$$m_N = 1.008665u$$

$$E \text{ in eV} = ?$$

$$E \text{ in J} = ?$$

Solution:

$$E = m_N \times 931.5$$

$$E = 1.008665 \times 931.5$$

$$E = 939.6 \text{ MeV}$$

$$E = 939.6 \times 10^6 \text{ eV}$$

$$E \text{ in J} = E \text{ in eV} \times 1.6 \times 10^{-19}$$

$$E \text{ in J} = 939.6 \times 1.6 \times 10^{-19}$$

$$E = 1.50 \times 10^{-16} \text{ J}$$

Problem # 19.6

Find the binding energy of ${}_{52}\text{Tc}^{126}$. Given

$$m_p = 1.0078u$$

$$m_N = 1.0086u$$

$$m_{\text{Tc}} = 125.9033u$$

$$1u = 931.5 \text{ MeV}$$

Solution:

$$\text{No. of protons} = 52$$

$$\text{No. of Neutrons} = 126 - 52$$

$$= 74$$

Mass of Tl in free stable

$$M = 52m_p + 74 m_N$$

$$M = 52 \times 1.0078 + 74 \times 1.0086$$

$$M = 52.4056 + 74.6364$$

$$M = 127.042u$$

Mass Defect

$$\Delta m = M - m_{\text{Tl}}$$

$$\Delta m = 127.042 - 125.9033$$

$$\Delta m = 1.1387u$$

$$E = \Delta m \times 931.5$$

$$E = 1.1387 \times 931.5$$

$$E = 1060.7 \text{ MeV}$$

Problem # 19.7

If the number of atom per gramme of ${}_{88}\text{Ra}^{226}$ is 2.666×10^{21} and it decays with a half life of 1622 years. Find the decays constant and the activity of the sample. (2013)

Data:

$$N_0 = 2.666 \times 10^{21}$$

$$T_{\frac{1}{2}} = 1622 \text{ years} = 5.11 \times 10^{10} \text{ sec}$$

$$\lambda = ?$$

$$A = ?$$

Solution:

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

$$\lambda = \frac{0.693}{T_{\frac{1}{2}}}$$

$$\lambda = \frac{0.693}{5.11 \times 10^{16}}$$

$$\lambda = 1.35 \times 10^{11} \text{ S}^{-1}$$

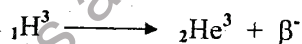
$$A = \lambda N^0$$

$$A = 1.35 \times 10^{11} \times 2.666 \times 10^{21}$$

$$A = 3.61 \times 10^{10} \text{ disintegration/sec}$$

Problem # 19.8

What will be the maximum energy electron in the beta decay of ${}_{1}\text{H}^3$ through the reaction.



Data:

$$\text{mass of } {}_{1}\text{H}^3 = 3.016049\text{u}$$

$$\text{mass of } {}_{2}\text{He}^3 = 3.016029\text{u}$$

$$E = ?$$

Solution:

Mass defect

$$\Delta m = \text{mass of } {}_{1}\text{H}^3 - \text{mass of } {}_{2}\text{He}^3$$

$$\Delta m = 3.016049 - 3.016029$$

$$\Delta m = 2.41 \times 10^{-4} \text{ u}$$

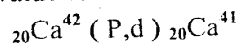
$$E = \Delta m \times 931.5$$

$$E = 2 \times 10^{-5} \times 931.5$$

$$E = 0.0186 \text{ MeV}$$

Problem # 19.9

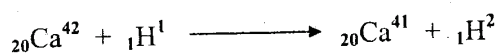
Find the Q-value for nuclear reaction.



Data:

Mass of ${}_{20}\text{Ca}^{42}$ = 41.928u
 Mass of ${}_{20}\text{Ca}^{41}$ = 41.9118u
 Mass of Proton = 1.0078u
 Mass of electron = 2.014102u
 Q-Value = ?

Solution:



mass of reactant, $m_1 = 41.928 + 1.0078$
 $m_1 = 42.9358\text{u}$

mass of product, $m_2 = 41.9118 + 2.014102$
 $m_2 = 43.926\text{u}$

Mass defect

$$\Delta m = m_2 - m_1$$

$$\Delta m = 43.926 - 42.9358$$

$$\Delta m = 0.9902\text{u}$$

$$\text{Q-value} = \Delta m \times 931.5$$

$$\text{Q-value} = 0.9902 \times 931.5$$

$$\boxed{\text{Q-value} = 924 \text{ MeV}}$$

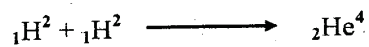
Problem # 19.10

Find the energy released when two deuterium (${}_1\text{H}^2$) nuclei fuse together to form an alpha particle (${}_2\text{He}^4$).

Data:

mass of deuterium = 2.014102u
 mass of alpha particle = 4.0026034
 E = ?

Solution:



Mass of reactant, $m_1 = 2.014102 + 2.014102$
 $m_1 = 4.0282\text{u}$

Mass Defect

$$\Delta m = \text{mass of two deuterium} - \text{mass of alpha particle}$$

$$\Delta m = 4.0282 - 4.002603$$

$$\Delta m = 0.0256\text{u}$$

$$E = \Delta m \times 931.5$$

$$E = 0.0256 \times 931.5$$

$$\boxed{E = 23.82 \text{ MeV}}$$

19.17 SOLVED NUMERICALS OF PAPERS:

YEAR 2013:

(Question# 19.7 of Book)

YEAR 2012:

Q.2(xii) Find the binding energy and binding fraction (Packing fraction) in MeV

of ${}_{52}\text{T}^{126}$ given that

$$m_p = 1.0078\text{U}, \quad m_n = 1.00866\text{U}, \quad m_{\text{Tc}} = 125.9033\text{U}$$

Similar to Q# 19.6

Ans. **B.E = 1.06×10^3 MeV**

B.F = 8.418 MeV/ Nucleon

YEAR 2010:

Q.2(xii) A deuteron (3.3431×10^{-27} kg) is formed when a proton (1.6724×10^{-27} kg) combine; calculate the mass defect and Binding Energy (in Mev) and a neutron (1.6748×10^{-27} kg)

Data:

$$\text{Mass of deuteron} = A = 3.3431 \times 10^{-27} \text{ kg}$$

$$\text{Mass of Proton} = M_p = 1.6724 \times 10^{-27} \text{ kg}$$

$$\text{Mass of Neutron} = M_N = 1.6748 \times 10^{-27} \text{ kg}$$

$$\text{No. of Proton} = Z = 1$$

$$\text{No. of Neutrons} = N = 1$$

$$\text{Mass defect} = \Delta m = ? \quad \text{B.E} = ?$$

Solution:

$$\Delta m = m - A = (Zm_p + NM_N) - A$$

$$\Delta m = (1 \times 1.6724 \times 10^{-27} + 1.6748 \times 10^{-27}) - A$$

$$\Delta m = (1.6724 \times 10^{-27} + 1.6748 \times 10^{-27}) - A$$

$$\Delta m = 3.3472 \times 10^{-27} - 3.3431 \times 10^{-27}$$

$$\Delta m = 0.0041 \times 10^{-27} \text{ kg}$$

$$\Delta m = 4.1 \times 10^{-30} \text{ kg}$$

Now

$$\text{B.E} = \Delta m C^2 = (4.1 \times 10^{-30}) (3 \times 10^8)^2$$

$$\text{B.E} = 4.1 \times 10^{-30} \times 9 \times 10^{16}$$

$$\text{B.E} = 3.69 \times 10^{-13} \text{ Joule}$$

But $1 \text{ ev} = 1.6 \times 10^{-19} \text{ Joule}$

$$\text{B.E} = \frac{3.69 \times 10^{-13}}{1.6 \times 10^{-19}} \text{ ev}$$

$$\text{B.E} = 2.30625 \times 10^6 \text{ ev}$$

Or

$$\text{B.E} = 2.30625 \text{ Mev}$$

YEAR 2009:

Q.8(d) If the number of atoms per gram of ${}_{88}\text{Ra}^{226}$ is 2.666×10^{21} and it decay with Half Life of 1622 years. Find the decay constant and the activity of the sample.

Solution:

SIMILAR TO QUESTION NO. 19.7

Answer:

- a) $\lambda = 1.35 \times 10^{-11} \text{ sec}^{-1}$
b) Activity = $A = 3.59 \times 10^{10} \text{ decay / sec}$

YEAR 2006:

Q.8(d) The Half Life of ${}_{104}\text{Po}^{210}$ is 140 days. By what percent does its activity decrease per week?

Solution:

SIMILAR TO QUESTION NO. 19.4

Answer:

$$\% \frac{\Delta A}{A} = 3.465\%$$

YEAR 2003:

If a neutron is converted entirely into energy, how much energy is produced? Express your answer in joule and in electron volt.

Given $m_N = 1.67 \times 10^{-27} \text{ Kg}$, $c = 3 \times 10^8 \text{ m/s}^2$.

Data:

$$m_N = 1.67 \times 10^{-27} \text{ Kg}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$\text{Energy} = E = ?$$

a) in Jole

b) in eV

Solution:

Energy in joules.

$$E = mc^2$$

$$E = (1.67 \times 10^{-27})(3 \times 10^8)^2$$

$$\boxed{E = 1.503 \times 10^{-10} \text{ J}}$$

Energy in eV

$$\text{As } 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$\therefore E = \frac{1.503 \times 10^{-10}}{1.6 \times 10^{-19}}$$

$$\boxed{E = 939.375 \text{ MeV}}$$

YEAR 2001:

Find the binding energy of ${}_{52}\text{Te}^{126}$ in MeV if the mass of a portion is 1.0078u, mass of neutron = 1.0086u, mass of Te atom = 125.9033u.

Data:

$$m_p = 1.0078\text{u}$$

$$m_N = 1.0086\text{u}$$

$$A = 125.9033\text{u}$$

$$\text{B.E of } {}_{52}\text{Te}^{126} = ?$$

Solution:

$$\text{No. of protons} = Z = 52$$

$$\text{No. of neutrons} = 126 - 52$$

$$N = 74$$

Mass of nucleus in free state

$$M = Zm_p + Nm_N$$

$$M = 52 \times 1.0078 + 74 \times 1.0086$$

$$M = 127.042\text{u.}$$

Mass defect

$$\Delta m = M - A$$

$$\Delta m = 127.042 - 125.9033$$

$$\Delta m = 1.1387\text{u}$$

$$\text{As } 1\text{u} = 931.5 \text{ MeV}$$

$$\therefore \text{B.E} = \Delta m \times 931.5$$

$$\text{B.E} = 1.1387 \times 931.5$$

$$\boxed{\text{B.E} = 1060.7 \text{ MeV}}$$

YEAR 1985:

The half life of radon is 3.80 days. What is the decay constant for radon?

Data:

$$T_{\frac{1}{2}} = 3.80 \text{ Days}$$

$$\lambda = ?$$

Solution:

$$T_{\frac{1}{2}} = 3.80 \times 24 \times 3600$$

$$T_{\frac{1}{2}} = 328320 \text{ sec.}$$

$$T_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

$$\text{OR } \lambda = \frac{0.693}{T_{\frac{1}{2}}}$$

$$\lambda = \frac{0.693}{32830}$$

$$\boxed{\lambda = 2.11 \times 10^{-6} \text{ S}^{-1}}$$