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.

$$ {}_{17}Cl^{35} + {}_{1}H^{1} \longrightarrow {}_{16}S^{32} + {}_{2}He^{4} $$

(alpha particle)

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:

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

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

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

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

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).

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

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

$$+1.999x = +1.004$$

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

$$X = 0.502$$

Percentage of 1st isotope $= 0.502 \times 100$

$= 50.2\%$

Percentage of 2nd isotope $= 100 - 50.2$

$= 49.8\%$

Problem # 19.4

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

Data:

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

$t = 1$ 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′

$A' = \lambda N$

Describe is activity per week = A-A′

$= \lambda N - \lambda N$

$= \lambda (N_0 - N)$ ——— (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

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

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

$N = 0.966 N_0$

eq. (1) = Decrease in activity per week $= \lambda (N_0 - 0.966 N_0)$

$= \lambda N_0 (1 - 0.966)$

$= 0.034 \lambda N_0$

Percentage decrease in activity per week $= \frac{0.034\lambda N_0}{A} \times 100$

$= \frac{0.034\lambda N_0}{\lambda N_0} \times 100$

$= 3.4\ \%$

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 in eV = ?

E in J = ?

Solution:

$E = m_N \times 931.5$

$E = 1.008665 \times 931.5$

$E = 939.6\ MeV$

$E = 939.6 \times 10^6\ eV$

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

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

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

Problem # 19.6

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

$m_P = 1.0078u$

$m_N = 1.0086u$

$m_{Te} = 125.9033u$

$1u = 931.5\ MeV$

Solution:

No. of protons = 52

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

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

$\Delta m = 127.042 - 125.9033$

$\Delta m = 1.1387u$

$E = \Delta m \times 931.5$

$E = 1.1387 \times 931.5$

$E = 1060.7\ MeV$

Problem # 19.7

If the number of atom per gramme of $_{88}Ra^{226}$ is 2.666 x 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:

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

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

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

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

$$A = \lambda N^0$$

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

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

Problem # 19.8

What will be the maximum energy electron in the beta decay of $_1H^3$ through the reaction.

$$_1H^3 \longrightarrow {}_2He^3 + \beta^-$$

Data:

mass of $_1H^3$ = 3.016049u

mass of $_2H^3e$ = 3.016029u

$E = ?$

Solution:

Mass defect

$\Delta m = \text{mass of } {}_1H^3 - \text{mass of } {}_2H^3$

$\Delta m = 3.016049 - 3.016029$

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

$E = \Delta m \times 931.5$

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

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

Problem # 19.9

Find the Q-value for nuclear reaction.

$$_{20}Ca^{42}\ (P,d)\ _{20}Ca^{41}$$

Data:

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

Solution:

$$_{20}Ca^{42} + {_1H^1} \longrightarrow {_{20}Ca^{41}} + {_1H^2}$$

mass of reactant, $m_1 = 41.928 + 1.0078$

$m_1 = 42.9358u$

mass of product, $m_2 = 41.9118 + 2.014102$

$m_2 = 43.926u$

Mass defect

$\Delta m = m_2 + m_1$

$\Delta m = 43.926 - 42.9358$

$\Delta m = 0.9902u$

Q-value = Δm x 931.5

Q-value = 0.9902 x 931.5

Q-value = 924 MeV

Problem # 19.10

Find the energy released when two deuterium ($_1H^2$) nuclei fuse together to form an alpha particle ($_2He^4$).

Data:

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

Solution:

$$_1H^2 + {_1H^2} \longrightarrow {_2He^4}$$

Mass of reactant, $m_1 = 2.014102 + 2.014102$

$m_1 = 4.0282u$

Mass Defect

Δm = mass of two deuterium – mass of alpha particle

$\Delta m = 4.0282 - 4.002603$

$\Delta m = 0.0256u$

$E = \Delta m \times 931.5$

$E = 0.0256 \times 931.5$

$E = 23.82$ 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 ${}_{52}T^{126}$ given that

$m_p = 1.0078U$, $m_n = 1.00866U$, $m_{Te} = 125.9033U$

Similar to Q# 19.6

Ans. **B.E = 1.06 × 103 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:

Mass of deuteron $= A = 3.3431 \times 10^{-27}$ kg
Mass of Proton $= M_p = 1.6724 \times 10^{-27}$ kg
Mass of Neutron $= M_N = 1.6748 \times 10^{-27}$ kg
No. of Proton $= Z = 1$
No. of Neutrons $= N = 1$
Mass defect $= \Delta m = ?$ B.E = ?

Solution:

$\Delta m = m - A = (Zm_P + NM_N) - A$
$\Delta m = (1 \times 1.6724 \times 10^{-27} + 1.6748 \times 10^{-27}) - A$
$\Delta m = (1.6724 \times 10^{-27} + 1.6748 \times 10^{-27}) - A$
$\Delta m = 3.3472 \times 10^{-27} - 3.3431 \times 10^{-27}$
$\Delta m = 0.0041 \times 10^{-27}$ kg
$\boxed{\Delta m = 4.1 \times 10^{-30} \text{ kg}}$

Now

$B.E = \Delta mC^2 = (4.1 \times 10^{-30})(3 \times 10^8)^2$
$B.E = 4.1 \times 10^{-30} \times 9 \times 10^{16}$
$\boxed{B.E = 3.69 \times 10^{-13} \text{ Joule}}$

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

$\therefore \quad B.E = \dfrac{3.69 \times 10^{-13}}{1.6 \times 10^{-19}} ev$

B.E = 2.30625 x 10^6 ev
Or
B.E = 2.30625 Mev

YEAR 2009:

Q.8(d)If the number of atoms per gram of $_{88}Ra^{226}$ is 2.666 x 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) $\lambda = 1.35 \times 10^{-11}\ sec^{-1}$
b) Activity = A = 3.59×10^{10} decay / sec

YEAR 2006:

Q.8(d)The Half Life of $_{104}Po^{210}$ 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 is joule and in electron volt. Given $m_N = 1.67 \times 10^{-27}$ Kg, $c = 3 \times 10^8\ m/s^2$.

Data:

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

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

Energy = E = ?

a) in Jole

b) in eV

Solution:

Energy in joules.

$E = mc^2$

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

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

Energy in eV

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

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

$\boxed{E = 939.375\ MeV}$

YEAR 2001:

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

Data:

$m_P = 1.0078u$

$m_N = 1.0086u$

$A = 125.9033u$

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

Solution:

No. of protons = Z = 52

No. of neutrons = 126 – 52

N = 74

<u>Mass of nucleus in free state</u>

$M = ZM_p + NM_N$

$M = 52 \times 1.0078 + 74 \times 1.00876$

$M = 127.042u.$

<u>Mass defect</u>

$\Delta m = M - A$

$\Delta m = 127.042 - 125.9033$

$\Delta m = 1.1387u$

As $1u = 931.5$ MeV

$\therefore$ B.E = $\Delta m \times 931.5$

B.E = 1.1387×931.5

B.E = 1060.7 MeV

YEAR 1985:

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

Data:

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

$\lambda = ?$

Solution:

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

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

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

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

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

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