Q13. Calculate the energy released in MeV in the following nuclear reaction:

$$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He} + \mathrm{Q}$$

$$\begin{bmatrix} Mass\ of\ {}^{238}_{92}\mathrm{U} = 238.05079\ \mathrm{u} \\ Mass\ of\ {}^{234}_{90}\mathrm{Th} = 234.043630\ \mathrm{u} \\ Mass\ of\ {}^{4}_{2}\mathrm{He} = 4.002600\ \mathrm{u} \\ 1\ \mathrm{u} = 931.5\ \mathrm{Me\,V/c^2} \end{bmatrix}$$

Answer : As per the given nuclear reaction we have

$$^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He} + \mathrm{Q}$$

We know that mass defect is the difference in mass between the original atom(Uranium) and constituent atoms (Thorium + Helium)

$$Mass\ defect = M_U - M_{Th} - M_{He}$$

$$= 238.05079 - 234.043630 - 4.002600$$

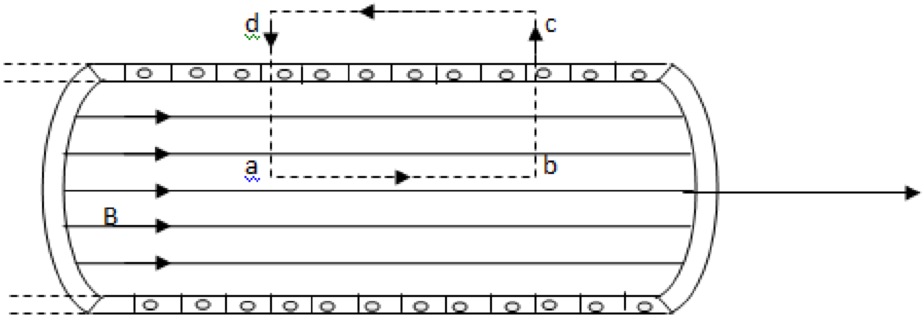
$$= 0.00456\ \mathrm{u}$$

$$\text{Energy released} = 0.00456\ \mathrm{u} \times 931.5\ \mathrm{Me\,V/c^2}$$

$$= 4.25\ \mathrm{Me\,V}$$

Q14. Using Ampere's circuital law, obtain an expression for the magnetic field along the axis of a current carrying solenoid of length *l* and having N number of turns.

Ans. **Magnetic field due to solenoid:** Considering a rectangular amperian loop *abcd* near the middle of solenoid as shown in the figure. Here length of the Solenoid =*l.*



Let the magnetic field along the path *ab* be B and is zero along *cd*. As the paths *bc* and *da* are perpendicular to the axis of solenoid, the magnetic field component along these paths is zero. Therefore, the path *bc* and *da* will not contribute to the line integral of magnetic field B.

Total number of turns in length *l* = N*l*.

The line integral of magnetic field induction B over the closed path abcd is

$$\oint_{abcd} \vec{B}\,\vec{dl} = \int_a^b \vec{B}\,\vec{dl} + \int_b^c \vec{B}\,\vec{dl} + \int_c^d \vec{B}\,\vec{dl} + \int_d^a \vec{B}\,\vec{dl}$$

$\because \int_a^b \vec{B}\,\vec{dl} = \int_a^b B\,dl\,\cos 0^\circ = Bl$

and $\int_b^c \vec{B}\,\vec{dl} = \int_b^c B\,dl \cos 90^\circ = 0 = \int_d^a \vec{B}\,\vec{dl}$

Also $\int_c^d \vec{B}\,\vec{dl} = 0 \quad [\because \text{Outside the solenoid}, B = 0]$

$\therefore \int_{abcd} \vec{B}\,\vec{dl} = Bl + 0 + 0 + 0 = Bl \ldots\ldots (i)$

Using Ampere's circuital law,

$\int_{abcd} \vec{B}\,\vec{dl} = \mu_0 \times \text{total current in rectangle abcd}$

$= \mu_0 \times \text{no. of turns in rectangle} \times \text{current}$

$= \mu_0 \times Nl \times I = \mu_0\,Nl\,I \ldots\ldots (ii)$

From (i) and (ii), we have

$Bl = \mu_0\,Nl\,I$

$\therefore B = \mu_0\,NI$

Q15. Derive an expression for the resistivity of a good conductor in terms of the relaxation time of electrons.

Answer. **Relation between the resistivity & relaxation time:** We know that drift velocity of electron is given by

$v_d = \frac{eE}{m}\tau$

but $E = \frac{V}{l}$

$\therefore v_d = \frac{e}{m}\frac{V}{l}\tau \Rightarrow V = \frac{v_d.ml}{e\tau}$

$\therefore$ *According to Ohm's law*,

$R = \frac{V}{I} = \frac{v_d.ml/e\tau}{neA\,v_d}$

$R = \frac{v_d.ml}{e\tau.neA\,v_d} = \frac{m}{n\,e^2\tau}.\frac{l}{A} \ldots\ldots (1)$

But the resistivity is given by

$R = \rho\,\frac{l}{A} \ldots\ldots\ldots (2)$

Comparing (1) & (2), we get

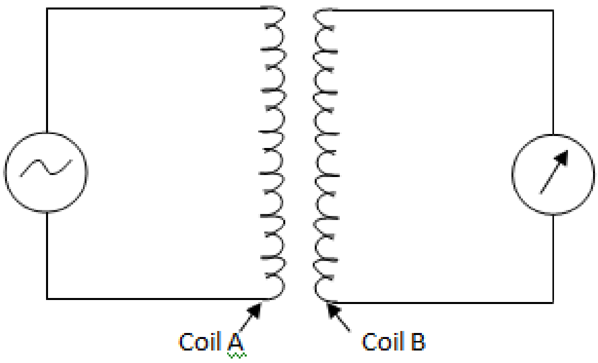
$$\rho = \frac{m}{n\,e^2\tau}$$

Which is required relationship between resistivity and relaxation time of electrons.

Q16. The circuit arrangement given below shows that when an a.c. passes through the coil A, the current starts flowing in the coil B.

(i) State the underlying principle involved.

(ii) Mention two factors on which the current produced in the coil B depends.



Answer

(i) The principle involved in the given circuit arrangement is **mutual induction.** When current flows through the coil, magnetic flux produced cuts the plane of the second coil and it induces emf in the second coil. Mutual induction is the property of two coils by virtue of which each opposes any change in the strength of current flowing through the other by developing an induced emf.

(ii) The current produced in the coil B depends on
   a. Number of turns in the coil.
   b. Nature of material.
   c. Distance between two coils.