"Abdullah-Al-Mamun" (CE-13) 1

Relativity

[illegible]

☒ What is special theory of relativity? Write the postulates of special theory of relativity. 13

The special theory of relativity is length / space, time and mass.

Postulates / General postulates of Einstein's special theory of relativity :-

① The laws of physics may be expressed in equations having the same form in all inertial frames of reference i.e., frames of reference moving at constant velocity with respect to one anothera.

(11) The velocity of light in free space (vacuum) is a constant (same for all observers), independent ~~not~~ not only of the direction of propagation but also of the relative velocity of the source and the observer.

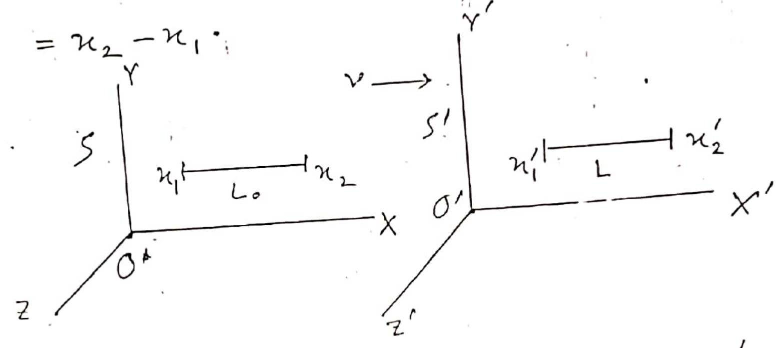
Define length contraction and time dilation and also derive their expressions. [13]

Length contraction: ~~Then~~ The length of an object is measured to be shorter when it is moving than when it is at rest.

Derivation: Let a rod of length L_0 parallel to the x axis and having the co-ordinates x_2 and x_1 in the reference frame S.

An observer in the reference frame S measures the length of the rod as

$L_0 = x_2 - x_1$.



Consider another reference frame S' which is with a velocity v. with respect to S. The observer measured the length from this frame.

$$L = x_2' - x_1'$$

According to inverse ~~length~~ Lorentz transformation we get,

$$x_1 = \frac{x_1' + vt'}{\sqrt{1 - v^2/c^2}} \quad \text{and} \quad x_2 = \frac{x_2' + vt'}{\sqrt{1 - v^2/c^2}}$$

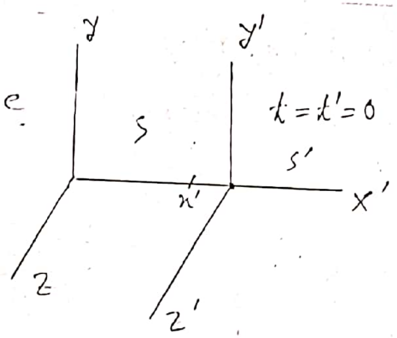
$\therefore L_0 = \dfrac{x_2' - x_1'}{\sqrt{1 - v^2/c^2}}$

$\Rightarrow L_0 = \dfrac{L}{\sqrt{1 - v^2/c^2}}$

$\therefore L = L_0 \sqrt{1 - v^2/c^2}$

<u>Time dilation:</u> The time measured with a reference frame at rest is larger ~~that~~ than the time measured from a reference frame moving with a constant velocity.

<u>Derivation:</u> Suppose at any instant the two reference frame co-incide at $t = t' = 0$. The observer in s' notes the time at any instant in his clock is t_1' and



and the observer in s notes the the time as t_1

Let t_2' and t_2 be the times measured by the two observer at the same instant. Consider t_0 be the interval of time as assumed by the observer in s' and t the interval of time measured by the observer in s.

$\therefore t_0 = t_2' - t_1'$ ——— (i)

$t = t_2 - t_1$ ——— (ii)

According to inverse of Lorentz transformation

$t_1 = \dfrac{t_1' + \frac{vx'}{c^2}}{\sqrt{1 - v^2/c^2}}$ and $t_2 = \dfrac{t_2' + \frac{vx'}{c^2}}{\sqrt{1 - v^2/c^2}}$

$\therefore t = \dfrac{t_2' - t_1'}{\sqrt{1 - v^2/c^2}}$ [From (i) and (ii)]

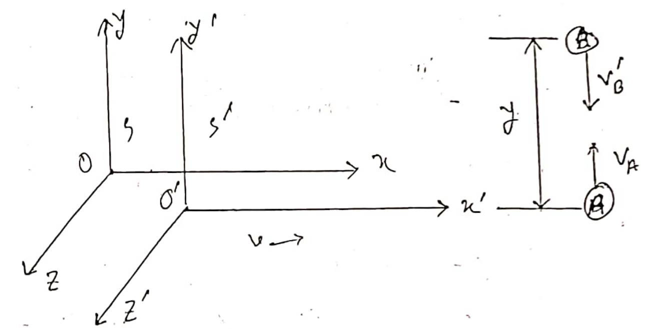
$\Rightarrow t = \dfrac{t_0}{\sqrt{1 - v^2/c^2}}$

☐ Define rest mass and effective mass of a body. Prove that the relativistic formula, $m = \frac{m_0}{\sqrt{1 - v^2/c^2}}$ $\boxed{12}$

Rest mass: The physical mass of a body when it is regarded as being rest. The mass of an object that is at rest relative to an observer is called rest mass. The increase in motion decreases the rest masses.

Effective mass: The physical mass of a body when it is regarded as being motion. The mass of an object that is in motion relative to an observer is called effective mass. The increase in motion, increases the effective mass of a body

Proof: consider the elastic collision between two particles A and B as witnessed by observers in the reference frame S and S' which are in uniform relative motion.



The frame S' is moving in the positive x direction with respect to S at the velocity v. Before the collision the particles A and B are respectively at rest in

S and S'. At the same instant A was thrown in the +y direction at the speed v_A and B was thrown in the -y direction at the speed v_B'.

$$\therefore v_A = v_B'$$

After collision A rebounds in the -y direction and B rebounds in the +y direction. Let the collision occurs at a distance $\frac{Y}{2}$.

$$\therefore y = y' = \frac{Y}{2}$$

The round trip time for A in S frame

$$T_0 = \frac{Y}{v_A} \text{ ——— (i)}$$

and hence for B in S' frame

$$T_0 = \frac{Y}{v_B'}$$

In S the speed v_B is found,

$$v_B = \frac{Y}{T} \text{ ——— (ii)}$$

where,

$$T = \frac{T_0}{\sqrt{1-v^2/c^2}}$$

$$\therefore v_B = \frac{Y\sqrt{1-v^2/c^2}}{T_0} \quad [\text{from (ii)}]$$

and for A the speed,

$$v_A = \frac{Y}{T_0}$$

According to the law of conservation of linear momentum,

$$m_A v_A = m_B v_B$$

$$\Rightarrow m_A \cdot \frac{Y}{T_0} = m_B \cdot \frac{Y\sqrt{1-v^2/c^2}}{T_0}$$

$$\Rightarrow m_A = m_B\sqrt{1-v^2/c^2}$$

$$\Rightarrow m_B = \frac{m_A}{\sqrt{1-v^2/c^2}}$$

If $m_A = m_0$ and $m_B = m$ then from the relation

$$m = \frac{m_0}{\sqrt{1-v^2/c^2}}.$$

Write the genral theory of relativity. [12]

General theory of relativity: The fundamental postulate of general theory of relativity is Einstein's equivalence principle. These theory based on gravitational field.

General relativity predicts the bending of light by gravity, gravitational time dilation and length contraction, a gravitational red shifts and blueshifts, the procession of Mercury's orbit and the existance of gravitational radiation.

Derive Einstein's mass-energy relation. [11]

Derivation: According to Newton's 2nd law of motion, we get;

$$F = \frac{d}{dt}(mv)$$

$$\Rightarrow F = m\frac{dv}{dt} + v\frac{dm}{dt} \quad \text{——— (i)}$$

Let force F is the cause of displacement dx. So, work done is $F \cdot dx$ and this work done is equal to kinetic energy.

$$dE_K = F \cdot dx$$

$$= \left(m\frac{dv}{dt} + v\frac{dm}{dt}\right)dx \quad \text{[From (i)]}$$

$$= m\frac{dv}{dt} \cdot dx + v\frac{dm}{dt}dx$$

$$= m\frac{dx}{dt} \cdot dv + v\frac{dx}{dt} \cdot dm$$

$$= mv\,dv + v^2 dm \quad \text{——— (ii)}$$

Again, we know,

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}$$

$\Rightarrow m^2 = \dfrac{m_0^2}{1 - v^2/c^2}$

$\Rightarrow m^2 = \dfrac{m_0^2 c^2}{c^2 - v^2}$

$\Rightarrow m^2c^2 - m^2v^2 = m_0^2c^2$

$\Rightarrow m^2c^2 = m_0^2c^2 + m^2v^2$ ——— (iii)

differentiating this equation,

$2m\,dm\,c^2 = 0 + 2m\,dm\,v^2 + 2v\,dv\,m^2$ $[d(m_0^2c^2)=0]$

$\Rightarrow dm\,c^2 = v^2 dm + mv\,dv$

From eqn (ii)

$dE_K = dm\,c^2$ ——— (iv)

when, $E_K = 0$, then $m = m_0$

" $E_K = E_K$ then $m = m$

Integrating eqn (iv),

$\int_0^{E_K} dE_K = c^2 \int_{m_0}^{m} dm$

$\Rightarrow E_K = c^2(m - m_0)$

$\Rightarrow E_K = mc^2 - m_0c^2$ ——— (v)

Total energy = Kinetic energy + rest mass energy

$\Rightarrow E = E_K + m_0c^2$

$\Rightarrow E = mc^2 - \cancel{m_0c^2} + \cancel{m_0c^2}$ [From (v)]

$\therefore E = mc^2$

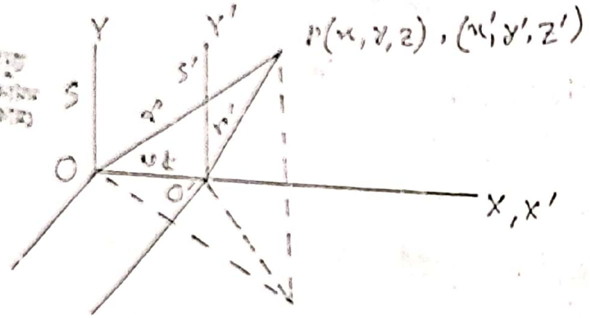
And this is the Einstein's mass energy relationship.

☐ Write a short note on Galileon's transformation.

Ans: The transformation of co-ordinates of a particle from one inertial frame of reference to another inertial frame of reference is called the Galileon's transformation.

Consider two inertial frames of reference ~~S (x,y,z) and~~ S and S'. The observer O' moves with a uniform velocity v relative to O along the x-axis, at time $t = 0$, O and O' are coincident. After time t,

$OO' = vt$



Now consider a particle at p.

Here, $r = r' + vt$

~~or, r' = r + t~~

$\Rightarrow r' = r - vt$

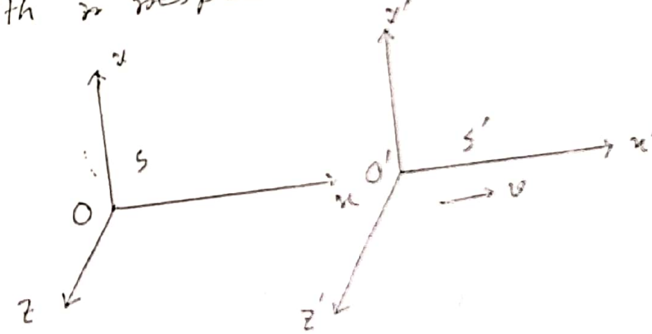
As v is parallel to x-axis separating the vector equation into three components

$$x' = x - vt$$
$$y' = y$$
$$z' = z \quad \text{and } t' = t$$

These set of equations are called ~~Galilean~~ Galilean's transformations because by using these equations, the results observed in one reference frame can be transformed the other reference frame.

㊃ Write a short note on Lorentz transformation.

Let consider two frame S and S'. S' moves with a uniform velocity v with respect to S.



When time $t = t' = 0$, the observers of the frame s measured

$$x = ct \quad \text{——— (i)}$$

and the observers of the frame s' measured

$$x' = ct' \quad \text{——— (ii)}$$

From Galileon's transformation,

$$x' = x - vt$$

and $x = x' + vt'$

We cosidered the ~~eqn~~ equation of the next time,

$$x' = k(x - vt) \quad \text{——— (iii)}$$

and $x = k(x' + vt')$ ——— (iv)

Here k does not depend on x and t

There is no relative velocity along y and z axis,

$$y' = y \quad \text{——— (v)}$$

$$z' = z \quad \text{——— (vi)}$$

But the magnitude of t and t' is not equ.

From eqn (iii) and (iv)

$$x = k[k(x - vt) + vt']$$

$$\Rightarrow x = k^2x - k^2vt + kvt'$$

$$\Rightarrow kvt' = x - k^2x + k^2vt$$

$$\Rightarrow t' = \left(\frac{1-k^2}{kv}\right)x + kt \quad \text{——— (vii)}$$

Substituting the value of (iii) and (vii) in eqn (ii)

$$k(x - vt) = c\left[\left(\frac{1-k^2}{kv}\right)x + kt\right]$$

$$\Rightarrow kx - kvt = ckt + \left(\frac{1-k^2}{kv}\right)cx$$

$$\Rightarrow x\left[k - \left(\frac{1-k^2}{kv}\right)c\right] = ckt + kvt$$

$$\Rightarrow x = \frac{ct\left(k + \frac{kv}{c}\right)}{\left[k - \left(\frac{1-k^2}{kv}\right)c\right]}$$

Substituting this value in eqn (i) we get,

(18)

$$\frac{ct\left(k+\frac{kv}{c}\right)}{\left[k-\left(\frac{1-k^2}{kv}\right)c\right]} = ct$$

$$\Rightarrow k + \frac{kv}{c} = k - \left(\frac{1-k^2}{kv}\right)c$$

$$\Rightarrow kv = -\left(\frac{1-k^2}{kv}\right)c^2$$

$$\Rightarrow k^2v^2 = -c^2 + k^2c^2$$

$$\Rightarrow k^2(c^2 - v^2) = c^2$$

$$\Rightarrow k^2 = \frac{c^2}{c^2 - v^2}$$

$$\Rightarrow k^2 = \frac{c^2/c^2}{c^2/c^2 - v^2/c^2}$$

$$\Rightarrow k^2 = \frac{1}{1 - v^2/c^2}$$

$$\therefore k = \frac{1}{\sqrt{1 - v^2/c^2}}$$

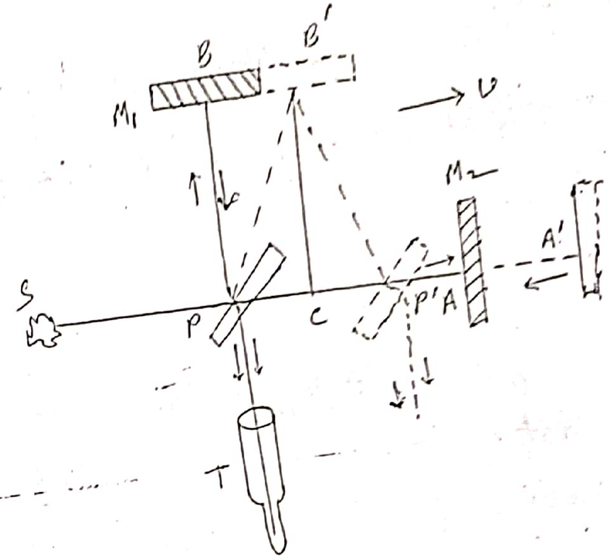
Substituting the value of k in eqn (iii) and (vii)

$$x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}} \quad \text{and} \quad x = \frac{x' + vt'}{\sqrt{1 - v^2/c^2}}$$

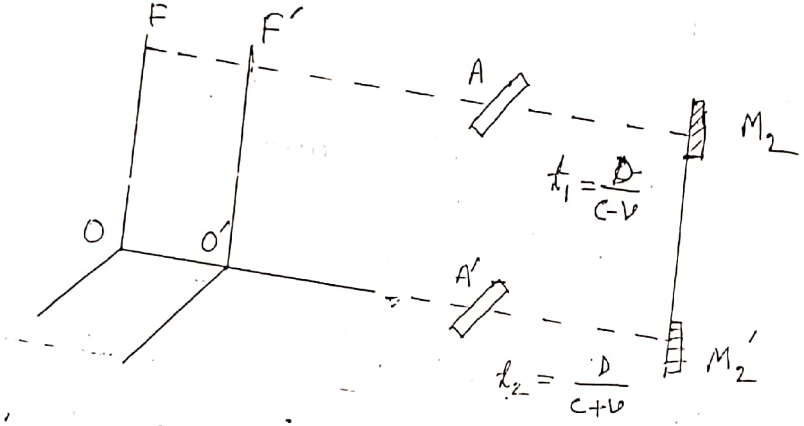
$$t' = \frac{t - vx/c^2}{\sqrt{1 - v^2/c^2}} \quad \text{and} \quad t = \frac{t' + vx'/c^2}{\sqrt{1 - v^2/c^2}}$$

And these equations are lorentz transformation.

(11) Describe Michelson-Morley experiment. Discuss the results obtained. $\boxed{09}$



Light from an extended monochromatic source S falls on a glass plate 'P' place at 45° to the beam. P is half-silvered on its right side and this surface reflects half of the light up towards M_1 while the other half is transmitted goes towards M_2. The reflected portion falls normally at B on M_1 and transmitted portion falls normally at A on M_2. Both M_1 and M_2 reflect their beams ~~to~~ back towards P. The beam from M_1 is partly reflected at P and remainder goes on through to the telescope T. A ~~prop~~ portion from M_2 is reflected at P and goes to telescope T and the rest goes through the glass plate and is lost.



F is a fixed frame corresponding to the ether medium and F' is the ref. reference frame moving with a velocity 'v'.

The velocity of the light in the direction of the movement of the frame F' = c−v and in opposite direction is c+v. Let t_1 be the time taken by light to travel from A to M_2 and t_2 be the time to travel from M_2' to A'.

The total time taken by light,

$$t = t_1 + t_2$$

$$= \frac{D}{c-v} + \frac{D}{c+v}$$

$$= \frac{2Dc}{c^2-v^2}$$

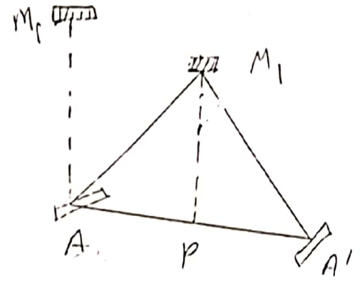
The total distance travelled by the light, $x_1 = t \times c$

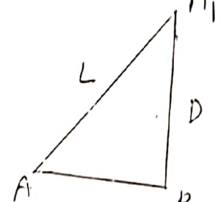
$$= \frac{2Dc^2}{c^2-v^2}$$

$$= 2D \left\{ \frac{c^2+v^2}{c^2} + \frac{v^4}{c^2(c^2-v^2)} \right.$$

$$\Rightarrow x_1 = 2D\left(1 + \frac{v^2}{c^2}\right) \text{ ——— (i)}$$

Let the time taken by the light to travel from A to M_1' be t'. Here M_1 is shifted to M_1' in the time A is shifted to P





The distance $AP = vt'$

But $t' = \frac{L}{c}$

$\therefore AP = \frac{vL}{c}$

From the triangle we get,

$$L^2 = D^2 + \left(\frac{vL}{c}\right)^2$$

$$\Rightarrow L^2\left(1 - \frac{v^2}{c^2}\right) = D^2$$

$$\Rightarrow L^2 = \frac{D^2}{\left(1 - \frac{v^2}{c^2}\right)}$$

$$\Rightarrow L = D\left(1 + \frac{v^2}{2c^2}\right) \quad \left[\text{because } \frac{v^2}{c^2} \ll 1\right]$$

$\therefore$ Total distance travelled by light in time t in going from A to M_1' and back to A' is

$$2L = 2D\left(1 + \frac{v^2}{2c^2}\right)$$

$$\therefore x_2 = 2D\left(1 + \frac{v^2}{2c^2}\right) \text{ ——— (ii)}$$

From eq^n (i) and (ii), path difference,

$$x_2 - x_1 = 2D\left(1 + \frac{v^2}{2c^2}\right) - 2D\left(1 + \frac{v^2}{c^2}\right)$$

$$= \frac{Dv^2}{c^2}$$

If the apparatus is turned through 90°, the path difference will be $-\frac{Dv^2}{c^2}$.

The displacement in the interference fringe is $\frac{Dv^2}{c^2}$.

This negative result suggests that

the velocity of light is invariable and remains constant in all directions.

Thus

⊞ Define photo electric effect and obtain the Einstein's photoelectric equation. $\boxed{10}$

Photoelectric effect: When light of sufficient high frequency (ultraviolet x-rays γ-rays etc) falls upon a metal surface, electrons are emited from it. This phenomena is known as photo-electric effect. The emitted electrons are called photoelectrons and the current constitutes by the electrons are calle photo-current or photo-electricity.

Einstein's photo-electric equation: Consider a photon of energy $h\nu$ incidents upon a metal surface and reject a photo-electron of velocity v then

$$h\nu = \frac{1}{2}mv^2 + W_0 \quad \text{—— (1)}$$

where, W_0 is the work done or energy

spend in just eject the electrons outside the surface of the metal.

If W_0 is the photo-electric work function ... then the frequency of light ν_0 is required for the purpose, given by,

$$W_0 = h\nu_0$$

$$\therefore \nu_0 = \frac{W_0}{h} \quad \text{(ii)}$$

Here, ν_0 is known as the threshold frequency. When a radiation of frequency, ν is greater than the threshold frequency, ν_0 then the difference in energy $(h\nu - h\nu_0)$ is used, so that.

$$h\nu = \frac{1}{2} m v_{max}^2 + W_0$$

$$\therefore h\nu = \frac{1}{2} m v_{max}^2 + h\nu_0 \quad \text{(iii)}$$

eqn (iii) is known as the Einstein's photo-electric equation.

Write down the laws of photoelectric effect $\boxed{07}$

(i) The strength of the photo-electric current (i.e. the numbers of electrons emitted per second) is directly proportional to the intensity of light or radiation used, provided the frequency of the radiation is kept constant.

(ii) Keeping intencity and frequency constan of incident light, the photo electric current will be decreased with the increase of retarding potential V.

(iii) The maximum velocity of an electron emitted varies linearly with the frequency of the incident light but is independent of its intensity.

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(iv) The photoelectric emission is an instantaneous process. If there is any time lag between the arrival of light of a metal surface and the emission photo-electrons, it should be less than 3×10^{-7} seconds.

(5) State and explain the compton effect. show that the wavelength of the scattered photon is greater than the wavelength of the incident photon. 12

Compton effect: The scattering of a photon by an electron is called the compton effect. Both energy and momentum are conserved in such an event and as a result the scattered photon has less energy than the incident photon.

A collision between the incident photon and an electron is showed in the figure below. In this process, an x-ray photo strikes on electron and is scattered away from its original direction of motion and begins to move.

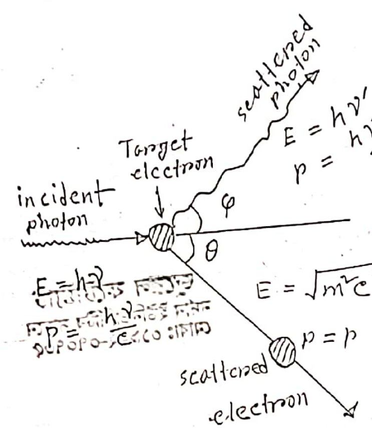

Fig: (a)

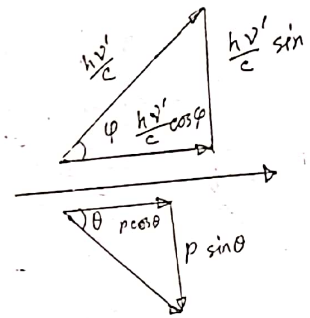

Fig: (b) vector diagram.

Then the photon is losing an amount energy in the collision, that is the same as the kinetic energy (KE) gained by the electron. If the incident photo has the frequency ν associated with it, the scattered photon has the lower frequency ν'

Loss in photon energy = gain in electron energy.

$$\Rightarrow \quad h\nu - h\nu' = KE \quad \text{——— (1)}$$

The momentum of massless particle is related to its energy by, $E = pc$ ——— (2)

Since the energy of a photon is $h\nu$, its momentum is

$$p = \frac{E}{c} = \frac{h\nu}{c} \quad \text{——— (3)}$$

The momentum of the incident and scattered photon are $\frac{h\nu}{c}$ and $\frac{h\nu'}{c}$ respectively and the electron are 0 and p.

Initial momentum = Final momentum

$$\Rightarrow \frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\varphi + p\cos\theta \quad \text{——— (4)}$$

and perpendicular to this directio

$$0 = \frac{h\nu'}{c}\sin\varphi - p\sin\theta \quad \text{——— (5)}$$

Here φ is the angle between the directions of the initial and scattered photons and θ is

Nuclear Physics

CE-13 NASIM

Nucleide :

If the number of proton and the number of neutron of two nucleous is equal then they included the same nuclear species. This nuclear species is called nucleide.

Isotope :

The atoms of an element which have the same atomic number but different mass number are called isotope. For example - Isotope of hydrozen.

$^{1}_{1}H \rightarrow$ Hydrogen, $^{2}_{1}H \rightarrow$ Deuterium, $^{3}_{1}H \rightarrow$ Tritium

Each contains the same atomic number but different mass number.

Isotone :

The atoms of an element which have the same number of neutrons but different atomic number and atomic masses are called isotones. For example -

$^{14}_{6}C$, $^{15}_{7}N$, $^{16}_{8}O$, each contain the same neutron number.

Isober :

The atoms which have the same mass number but different atomic numbers are called Isobers. For example,

$^{13}_{7}N$ and $^{13}_{6}C$

Each contains the same mass number but different atomic number.

Isomer :

If the two nucleous of same species are in two different energy level and atleast if one of them is metastable then they are called isomer.

Nuclear radius :

The distance between the centre of the nucleous and its perimeter is called nuclear radius. It is denoted by R.

Mass defect :

Nucleous of an atom is consist of proton and neutron. So the mass of nucleous should be the sum of mass of proton and the mass of neutron. But the total sum of the mass of proton and the mass of neutron is slightly greater than the mass of nucleous. This defect is called mass defect. It is denoted by ΔM.

$$\therefore \Delta M = Z \times M_p + (A-Z) M_n - M_{(p+n)}.$$

Binding energy :

Binding energy is defined as the equivalent energy of the mass defect. It is denoted by B_E.

If ΔM be the mass defect and c be the velocity of light then binding energy,

$$B_E = \Delta M c^2$$

Again $\Delta M = [Z \times M_p + (A-Z) \times M_n - M_{(p+n)}]$

so binding energy.

$$B_E = [Z \times M_p + (A-Z) \times M_n - M_{(p+n)}] c^2.$$

Packing fraction :

Packing fraction is the ratio between the difference of mass and mass number and the mass number.

It is denoted by Pf.

$$Pf = \frac{\text{Atomic mass} - \text{Mass number}}{\text{Mass number}}$$

Mirror nucleous :

If in the nucleous of the two atoms the no of neutrons of the first atom is equal to the number proton of second atom and vice versa, then they are called mirror nucleous.

Example,

$^{15}_{7}N$, $^{15}_{8}O$

Nuclear reaction :

When a nuclear particle is incident on a target nucleous then if the energy and structure of target nucleous are changed, then it is called nuclear reaction.

On the base of reactions step there are two types of nuclear reaction.

1) Direct nuclear reaction

2) Compound nuclear reaction.

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...netic energy is defined E_a and potential energy is m_ac^2 then,

$$(E_a + m_ac^2) + (0 + m_xc^2) = (E_y + m_yc^2) + (E_b + m_bc^2)$$

$$\Rightarrow (E_y + E_b) - E_a = [(m_a + m_x) - (m_y + m_b)]c^2$$

Here,

$(E_y + E_b) - E_a$ is known as Q value.

and $[(m_a + m_x) - (m_y + m_b)]c^2$ is one kind of binding energy.

So Q value is one kind of binding energy.

Significance of Q-value :

We know, Q-value $= (E_y + E_b) - E_a$ ...... (1)

(i) Exothermic reaction :

When Q value > 0 then the reaction will be exothermic reaction i.e. in the case of exothermic reaction

$$E_y + E_b > E_a.$$

(ii) Endothermic reaction :

When Q-value < 0 then the reaction will be endothermic reaction, i.e. in the case of endothermic reaction

$$E_y + E_b < E_a.$$

Direct nuclear reaction :

This type of reaction is completed over by one step.

For example,

$${}^{2}_{1}H + {}^{2}_{1}H \longrightarrow {}^{4}_{2}He + \text{energy}.$$

Compound nuclear reaction :

This type of reaction is completed over by two steps.

a) Unstable step -

$${}^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{236}_{92}U$$

... Unstable step.

b) Stable step -

$${}^{236}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + \text{energy}.$$

Stable step.

Q-value of nuclear reaction :

Q value is one kind of energy. The kinetic energy difference between the incident particle and productive energy is called Q-value energy.

Equation Q value energy :

We consider a general equation

$$a + X = Y + b.$$

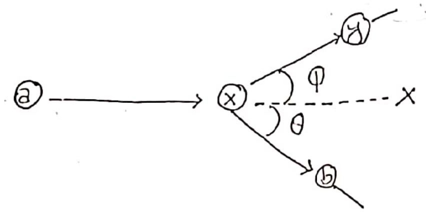
Elastic reaction :

When Q-value $=0$, then the reaction will be elastic reaction i.e. in the case of elastic reaction

$$E_y + E_b = E_a.$$

Determination of Q- value :

Prove that $\rightarrow$ $Q = E_b\left(1 + \frac{m_b}{m_y}\right) - E_a\left(1 - \frac{m_a}{m_y}\right)$.



Let us consider a reaction,

$a + X = Y + b.$

The mass velocity equation can be written as

$m_a v_a + 0 = m_y v_y \cos\varphi + m_b v_b \cos\theta$ in x axis ...... (i)

or, $m_y v_y \cos\varphi = m_a v_a - m_b v_b \cos\theta$ .... (ii)

In Y axis the equation can be written as,

$m_y v_y \sin\varphi - m_b v_b \sin\theta = 0$

or, $m_y v_y \sin\varphi = m_b v_b \sin\theta$ ..... (iii)

Squaring and adding (ii) and (iii) we get,

$$m_y^2 v_y^2 (\sin^2\varphi + \cos^2\varphi) = m_b^2 v_b^2 (\sin^2\theta + \cos^2\theta) + m_a^2 v_a^2 - 2 m_a v_a m_b v_b \cos\theta$$

$$\Rightarrow m_y^2 v_y^2 = m_b^2 v_b^2 + m_a^2 v_a^2 - 2 m_a v_a m_b v_b \cos\theta$$

$$\Rightarrow \frac{1}{2} m_y^2 v_y^2 = \frac{1}{2} m_b^2 v_b^2 + \frac{1}{2} m_a^2 v_a^2 - m_a v_a m_b v_b \cos\theta.$$

[multiplying by ½]

$$\Rightarrow \frac{1}{2} m_y v_y^2 (m_y) = \frac{1}{2} m_b v_b^2 (m_b) + \frac{1}{2} m_a v_a^2 (m_a) - 2 \frac{(m_a^2 v_a^2 m_b^2 v_b^2)^{1/2}}{4} \cos\theta.$$

$$\Rightarrow E_y m_y = E_b m_b + E_a m_a - 2\left[\left(\tfrac{1}{2} m_a v_a^2\right) m_a \left(\tfrac{1}{2} m_b v_b^2\right)(m_b)\right]^{1/2} \cos\theta$$

$$\Rightarrow E_y m_y = E_b m_b + E_a m_a - 2\left[E_a m_a E_b m_b\right]^{1/2} \cos\theta.$$

$$\Rightarrow E_y = E_b \frac{m_b}{m_y} + E_a \frac{m_a}{m_y} - \frac{2}{m_y}\left[E_a m_a E_b m_b\right]^{1/2} \cos\theta \quad \text{.......(iv)}$$

We know, $Q = (E_y + E_b) - E_a$.

$$\Rightarrow Q = E_b \cdot \frac{m_b}{m_y} + E_a \frac{m_a}{m_y} - \frac{2}{m_y}\left[E_a m_a E_b m_b\right]^{1/2} \cos\theta + E_b - E_a.$$

$$\Rightarrow Q = E_b\left(1 + \frac{m_b}{m_y}\right) - E_b\left(1 - \frac{m_a}{m_y}\right) - \frac{2}{m_y}\left[E_a m_a E_b m_b\right]^{1/2} \cos\theta.$$

when $\theta = 90^\circ$, then

$$Q = E_b\left(1+\frac{m_b}{m_y}\right) - E_a\left(1-\frac{m_a}{m_y}\right)$$

This is the required equation.

Nuclear fission:

The process in which a heavy nucleous split up into two or more nuclei of comparable masses is called nuclear fission. For example.

$${}_0^1n + {}_{92}^{235}U \longrightarrow {}_{92}^{236}U^* \longrightarrow {}_{56}^{141}Ba + {}_{36}^{92}Kr + 3\,{}_0^1n + \text{Energy}$$

Nuclear fusion:

In this process small nuclei are fused together to form a single heavy nucleous.

For example –

$${}_1^2H + {}_1^2H \rightarrow {}_2^4He + \text{energy}.$$

Chain reaction:

Chain reaction is a self sustain process where there is no need of any excess energy to continue the process. A chain reaction can be obtained by the neutron from a fissionable reaction.

$${}_{92}^{235}U + {}_0^1n \rightarrow \left[{}_{92}^{236}U\right]^* \rightarrow {}_{56}^{141}Ba + {}_{36}^{92}Kr + 3\,{}_0^1n + \text{Energy}.$$

[Mod]erator:

For moderatoring cd rods, Graphaite, and furness water and light are used which are –

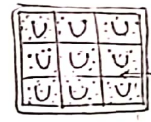
1. Graphaite and furness water decrease the speed of neutrons.
2. cd-rods are used for absorbing the slow neutron.
3. Light is used for producing energy

For the above moderator the chain reaction is under controlled by the nuclear reactor.

Nuclear reactor:

In which device is controlled the chain reaction of nuclear reaction can be initiated and sustained to produce energy is known as nuclear reaction.

Principle:



Here ${}_{92}^{235}U$ atom is used and as many ${}_{92}^{235}U$ atoms are taken, they are covered by silgala. Where neutron comes and give force on the target nucleous for creating chain reaction of nuclear reaction.

[G]raphite, furness water → decrease speed of neutro[n]

cd rods → absorb slow neutron

L → Produce energy

Radioactive equillibrium :

The disintegration of radioactive atom is taken place at the equal rate which is called the radioactive equillibrium.

Expression :

$$\underset{\lambda_a}{\overset{N_a}{ⓐ}} \longrightarrow \underset{\lambda_b}{\overset{N_b}{ⓑ}} \longrightarrow \underset{\lambda_c}{\overset{N_c}{ⓒ}} \longrightarrow \cdots\cdots \underset{\lambda_n}{\overset{N_n}{ⓝ}}$$

From the figure, a is broken and make b, then c is made from b, upto happen at n.

Here, N = No of atom which are not decay.

λ = The decay constant.

Here the net ret of production of $a \rightarrow b$

$$\frac{dN_b}{dt} = \left|\frac{dN_a}{dt}\right|_{a\rightarrow b} - \left|\frac{dN_b}{dt}\right|_{b\rightarrow c}$$

$$\Rightarrow \frac{dN_b}{dt} = \lambda_a N_a - \lambda_b N_b .$$

$$\Rightarrow \frac{dN_b}{dt} + \lambda_b N_b = \lambda_a N_a . = \lambda_a N_a^0 . e^{-\lambda_a t}$$

$$\Rightarrow e^{\lambda_b t} . \frac{dN_b}{dt} + \lambda_b . N_b . e^{\lambda_b t} = \lambda_a N_a^0 . e^{(\lambda_b - \lambda_a)t}$$

[Multiplying by $e^{\lambda_b t}$]

$$\frac{d}{dt}(N_b . e^{\lambda_b t}) = \lambda_a . N_a^0 . e^{(\lambda_b-\lambda_a)t} .$$

$$\Rightarrow N_b . e^{\lambda_b t} = \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 . e^{(\lambda_b - \lambda_a)t} + c \;\cdots\cdots (1)$$

[by integrating]

When $t = 0$, $N_b = 0$

$$c = -\frac{\lambda_a}{\lambda_b - \lambda_a} . N_a^0 .$$

$$\text{From } (1) \Rightarrow N_b . e^{\lambda_b t} = \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 \left[e^{(\lambda_b - \lambda_a)t} - 1\right]$$

$$\therefore N_b = \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 \left[e^{-\lambda_a t} - e^{-\lambda_b t}\right]$$

Kinds of radioactive equillibrium :

There are two kinds of radioactive equillibrium which are as following -

1. Secular equillibrium :

For this the condition must be applied,

$t_a \gg t_b$. where

$\lambda_b \gg \lambda_a$. $\because \bar{t} = 1/\lambda$.

From the resulting radioactive equillibrium,

$$N_b = \frac{\lambda_a}{\lambda_b - \lambda_a} . N_a^0 \left[e^{-\lambda_a t} - e^{-\lambda_b t}\right]$$

$$\Rightarrow N_b = \frac{\lambda_a}{\lambda_b} . N_a^0 . e^{-\lambda_a t} .$$

$$\Rightarrow N_b \lambda_b = \lambda_a N_a \;\cdots\cdots (1)$$

For secular equillibrium $N_b \lambda_b = N_a \lambda_a = N_c \lambda_c = \cdots\cdots = N_n \lambda_n$.

Tangential equilibrium:

For this the condition must be applied

$t_a > t_b$.

or, $\lambda_b > \lambda_a$.

So, result of radioactive equilibrium,

$$N_b = \frac{\lambda_a}{\lambda_b - \lambda_a} \cdot N_0 \cdot [e^{-\lambda_a t} - e^{-\lambda_b t}]$$

$$\Rightarrow N_b = \frac{\lambda_a}{\lambda_b - \lambda_a} \cdot N_a \cdot e^{-\lambda_a t}$$

$$\Rightarrow N_b = \frac{\lambda_a}{\lambda_b - \lambda_a} \cdot N_a.$$

$$\therefore N_a \lambda_a = N_b \cdot (\lambda_b - \lambda_a)$$

$$= N_c(\lambda_c - \lambda_b) = \dots\dots\dots = N_n(\lambda_n - \lambda_{n-1}).$$

Activity of radioactive atom:

The rate of disintegration is known as the activity of radioactive atom.

Radioactivity:

The phenomenon of emission of radioactive rays from the radioactive element is called radioactivity.

The S.I. unit of radioactivity is Becquerel which is represented by Bq.

1 Bq. = 1 decay-s^{-1}.

Characteristics of radioactive metal:

The characteristics of radioactivity are given below -

1) The atomic number of radioactive elements are greater than 82.

2) The atomic mass of radioactive element is greater than 206.

3) Radioactive element emitts three kinds of ray. They are alpha, beta and gamma ray.

4) Radioactivity is completely a nuclear phenomenon.

5) Radioactivity is a spontaneous phenomenon.

6) The materials should radiate positive, negative and nutral rays.

7). The materials don't depend on the external element.

8) The rate of disintegration or decay is spontaneous.

Radioactive decay law:

The rate of disintegration is directly proportional to the number of atoms present.

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

Suppose at any time t there are N radioactive atoms. Let the number of atoms dN disintegrate in time dt.

Mathematically, $-\frac{dN}{dt} \propto N$ ...... ①

The negative sign shows that with the increase in disintegration the value of N decreases.

$$\frac{dN}{dt} = -\lambda N. \quad [\lambda \text{ is the radioactive decay constant}]$$

$$\therefore \frac{dN}{N} = -\lambda dt.$$

Integrating $\int \frac{dN}{N} = \int -\lambda dt$

$$\Rightarrow \log_e N = -\lambda t + K \text{ ...... (ii)}$$

where K is a constant.

When, $t=0$. $N = N_0$

Where, N_0 is the number of atoms originally present

$$\log_e N_0 = K.$$

Substituting this value of K in equ. (ii)

$$\log_e N = -\lambda t + \log_e N_0$$

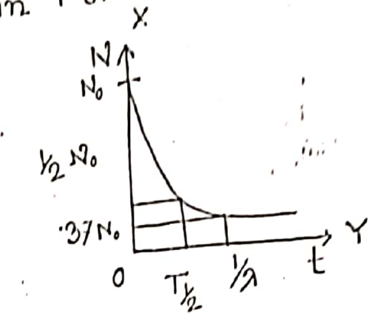
$$\Rightarrow \log_e \frac{N}{N_0} = -\lambda t$$

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

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

This equation is known as radioactive transformation equation.

a graph is plotted when, t is in X axis and N_0 is in Y axis substituted.



Half life period :

The half life period of a radioactive substance is defined as the time required for one half of the radioactive substance to disintegrate. The half life period is different for different substances and depends upon the radioactive constant of a substance.

Half life period is denoted by. $T_{1/2}$

We know. $N = N_0 e^{-\lambda t}$ ..... (i)

In this equation when, $t = T_{1/2}$ then $N = \frac{N_0}{2}$

$$\therefore \frac{N_0}{2} = N_0 . e^{-\lambda T_{1/2}}$$

$$\Rightarrow \frac{1}{2} = e^{-\lambda T_{1/2}}$$

$$\Rightarrow \ln(\tfrac{1}{2}) = -\lambda T_{1/2}$$

$$\Rightarrow \ln 1 - \ln 2 = -\lambda T_{1/2}$$

$$\Rightarrow \ln 2 = \lambda T_{1/2}$$

$$\Rightarrow T_{1/2} = \frac{\ln 2}{\lambda} = \frac{.693}{\lambda} \text{ .... (ii)}$$

Inc : !

From this equation it is seen that half life period is inversely proportional to radioactive decay constant and radioactive decay follows the exponential law.

Mean life :

Mean life is defined as the summation of life of atom of radioactive substance divided by initial number of atom. It is denoted by τ.

$\tau \quad \tau = \frac{1}{\lambda} \quad \tau \quad \tau$

Suppose,

The number of atoms at the begining $= N_0$

At time t. The number of atoms $= N$.

and dN atoms disintegrate between t and $(t+dt)$

It means that $(-dN)$ atoms have lived for a time t.

Therefore total life of $(-dN)$ atoms $= (-dN)t$

$\tau \quad \tau = \frac{1}{\lambda} \quad \lambda \quad \tau$

Since all the atoms disintegrate in time from zero to infinity, the sum of the life periods of all the atoms.

$$= \int_0^\infty (-dN)t$$

But, $\tau = \dfrac{\text{sum of the life periods of all the atoms}}{\text{Total number of atoms}}$

$$\Rightarrow \tau = \frac{\int_0^\infty (-dN)t}{N_0} \text{ ------ (1)}$$

$\tau \quad \tau \quad \tau$

$$\frac{dN}{dt} = -\lambda N$$

$$\Rightarrow dN = -\lambda N\, dt.$$

$$\Rightarrow dN = -\lambda N_0 e^{-\lambda t} dt. \quad [\because N = N_0 e^{-\lambda t}]$$

Substituting the value of dN in equ. (1)

$$\therefore \tau = \frac{\int_0^\infty \lambda N_0 e^{-\lambda t} dt \cdot t}{N_0}$$

$$\therefore \tau = \lambda \int_0^\infty t e^{-\lambda t} dt.$$

Integrating by parts,

$$\tau = \lambda \left[\frac{te^{-\lambda t}}{-\lambda} \right]_0^\infty - \left[\frac{e^{-\lambda t}}{\lambda} \right]_0^\infty$$

$$\tau = \frac{1}{\lambda} \text{ ...... (II)}$$

This is the equation of mean life.

Relationship between half life and mean life :

We know,

$$t_{1/2} = \frac{.693}{\lambda}$$

and $\tau = \frac{1}{\lambda} \Rightarrow \lambda = \frac{1}{\tau}$

Substituting the value of λ in equ. (III)

$$T_{1/2} = .693\,\tau \text{ ..... (IV)}$$

So, half life is proportional to mean life.

This is the relationship between half life and mean life.

Decay constant :

The possibility of disintegration in unit time of a atom of radioactive metal is called decay constant. It is denoted by λ.

The unit of decay constant is s^{-1}.

Difference between nuclear fusion and fission :

Nuclear fission	Nuclear fusion
1) The division of nucleous into two approximately equal parts is called nuclear fission.	1) The process by which two higher nuclei come to a stable state and form a heavier nuclei and a large amount of energy released is called fusion.
2) The links of the fission process are neutrons.	2) The links of a fusion process are protons.
3) Fission proceeds best with thermal neutrons where thermal means room temp.	3) Fusion proceeds best with thermal particles.
4) Atomic bomb is based on the principle of nuclear fission.	4) The hydrogen bomb is based on the principle of nuclear fusion.
5) Fission involves breaking up of a heavy nucleous into nuclei.	5) Fusion involves combining of two higher nuclei into one heavy nucleous.

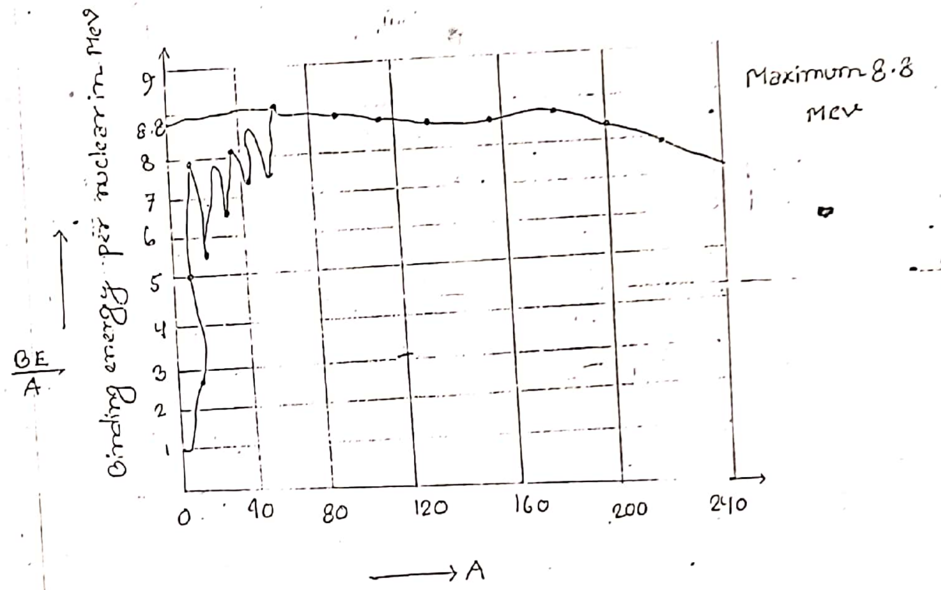
Binding energy and nuclear stability :

The average binding energy is defined as binding energy per nucleon. It is given by $\frac{BE}{A}$

$$\frac{BE}{A} = c^2\left[M_n - \frac{Z}{A}(M_n - M_p) - \frac{M(p+n)}{A}\right]$$

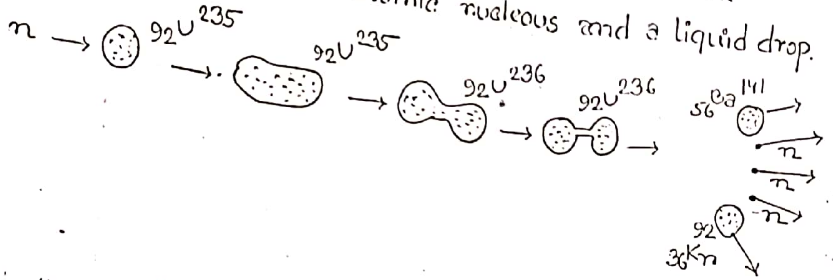
The binding energy of a nucleous gives a quantitative measure of its stability. Greater the binding energy more stable the nucleous.

Graph $\rightarrow \frac{BE}{A}$ vs Mass Number A.



Liquid drop model of a Nuclear reaction :

The model was proposed by Neils Bohr. He proposed the similarities between an atomic nucleous and a liquid drop.



① In the stable state a nucleous is supposed to be spherical in shape, just a liquid drop is spherical due to the symmetrical surface tension forces and the coulomb forces of repulsion.

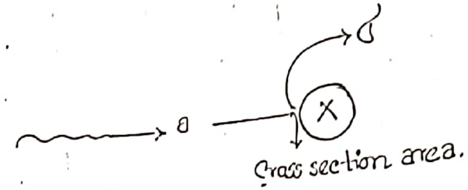
② When the force of the surface tention acts on the surface of the Liquid drop. There is a potential barrier at the surface of the nucleous

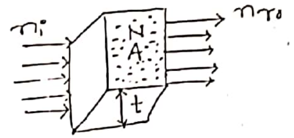
③ When some energy is imparted to the drop say through the capture of a neutron, oscillations are set up in the drop which tend to distort the spherical shape of the nucleous while the surface tention forces try to restore when the excitation energy is sufficiently large, the compound nucleous formed is in an excited state and is sufficiently distorted in shape Like that of a dumb-bell.

(i) When the coulomb force of repulsion between the two halves of this dumb-bell exceeds the nuclear forces holding the nucleons. The nucleous breaks up into two fragments and fission is said to take place. The various steps from neutron capture to fission of U^{235}_{92} nucleous are shown in above figure.

Cross section of a nuclear reaction :

The exposed area for Nucleous reaction of Nucleous is called the cross sectional area of this nuclear reaction. It is denoted by σ.





σ σ σ

Suppose we have a slab of some material whose area is A and whose thickness is t. Then volume of the slab = At

Let the material contain N atoms per unit volume !

Then, total number of nuclei in the slab = NAt

Further we assume that each nucleous has a cross section σ for some particular interaction.

(সমষ্টি) Aggregate cross section for all the nuclei in the slab = σNAt

Let, n_i be the number of incident particle in a bombarding beam and n_r is the number of particles that interact with nuclei in the slab, then

output/input $= \frac{\text{Number of interacting particles}}{\text{Number of incident particles}} = \frac{\text{Aggregate cross-section}}{\text{Target Area}}$

$$\frac{n_r}{n_i} = \frac{\sigma NAt}{A} = \sigma Nt$$

$$\therefore \sigma = \frac{1}{Nt} \cdot \frac{n_r}{n_i}$$

Threshold energy:

Threshold energy is a minimum required energy to start a reaction. It is denoted by E_{th}.

$$\therefore E_{th} = -Q\left(1 + \frac{m_a}{m_y}\right)$$

Equation of threshold energy:

To find threshold energy consider a intermediate stage when a compound nucleous is formed by the combination of the incident particle 'a' and the target particle 'x'.

$$\rightsquigarrow (a) + (x) \longrightarrow (a)(x)$$

Complex

$$\underset{m_a v_a}{(a)} \longrightarrow \underset{m_c v_c}{(c)}$$

To find threshold energy consider a intermediate stage when a compound nucleous is formed by the combination of the incident particle 'a' and the target particle 'x'.

The mass of the compound nucleous

$$m_c = m_a + m_x$$

and Energy, $E_c = E_y + E_b$ [For considering intermediate stage]

According to the conservation of linear momentum,

$$m_a v_a = m_c v_c$$

$$\therefore v_c = \frac{m_a v_a}{m_c}$$

$$\therefore v_c = \frac{m_a v_a}{m_a + m_x}$$

Now, Q value $= E_y + E_b - E_a$.

$Q = E_c - E_a$. [for intermediate stage]

or, $-Q = E_a - E_c$

or, $-Q = \frac{1}{2} m_a v_a^2 - \frac{1}{2} m_c v_c^2$

or, $-Q = \frac{1}{2} m_a v_a^2 - \frac{1}{2}(m_a + m_x)\left(\frac{m_a v_a}{m_a + m_x}\right)^2$

or, $-Q = \frac{1}{2} m_a v_a^2 - \frac{1}{2}\frac{m_a^2}{m_a + m_x} \cdot v_a^2$.

or, $-Q = \frac{1}{2} m_a v_a^2 \left(1 - \frac{m_a}{m_a + m_x}\right)$

or, $-Q = \frac{1}{2} m_a v_a^2 \left(\frac{m_a + m_x - m_a}{m_a + m_x}\right)$

or, $-Q = \frac{1}{2} m_a v_a^2 \frac{m_x}{m_a + m_x}$

or, $-Q = E_{th} \frac{m_x}{m_a + m_x}$. $\left[\because E_{th} = \frac{1}{2} m_a v_a^2\right]$

$$\therefore E_{th} = -Q\left(1 + \frac{m_a}{m_x}\right)$$

which is the threshold energy equation.

Radioactivity and decay constant relation:

We know that, radiation per second of a material is known as radioactivity

So $A = \frac{dN}{dt} = \lambda N$

$\Rightarrow A = \lambda N \ldots\ldots (i)$

$\therefore A_0 = \lambda N_0 \ldots\ldots (ii)$

From (i) and (ii),

$$\frac{A}{A_0} = \frac{\lambda N}{\lambda N_0} = \frac{N_0 e^{-\lambda t}}{N_0}$$

$$\therefore A = A_0 \cdot e^{-\lambda t}$$

Types of radioactivity:

1. Natural Radioactivity.
2. Artificial Radioactivity

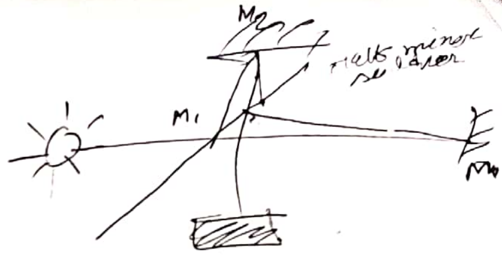
1. Natural radioactivity:

The radioactivity which exhibited by elements as found in nature is known as natural radioactivity.

2. Artificial radioactivity:

The radioactivity which exhibited or produced artificially is known as artificial radioactivity. It has a short half lives. They emit electrons, positrons and other particles as well as gamma rays in their disintegration.

25-08-2018



Relativity

The process of relative measurement of a characteristics of a body.

→ The measurement of one body with respect to another body

1) Special Theory of relativity : Mass, Space, time
2) General " " " : All of the universe

Special Theory

Reference Frame: When a body is selected by 3D characteristics, that body is called the reference frame.

This is of 2 kind : 1) Inertial Reference Frame
2) Non " "

Inertial frame : যদি পরস্পরের সাপেক্ষে সুষমবেগে গতিশীল হয় (same acceleration) তবে সে Inertial

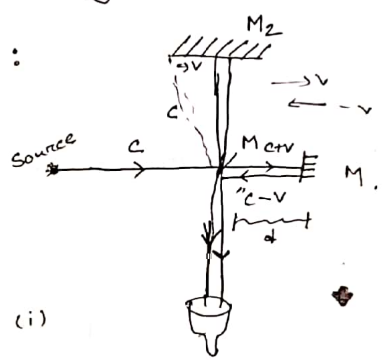
Non- " " : যদি পরস্পরের সাপেক্ষে different বেগে গতিশীল হয় (Different acceleration) তবে Non-inertial

Postulates of the special theory of ~~int~~ inertial.
1) যদি Inertial frame হয় তাহলে ঐ সব frame এর যেকোনো এক frame physics এর সকল সূত্র একইভাবে প্রমাণ করা যায়।

2) Light এর velocity সবসময় constant হয়। এটি light source and observer এর relative position এর নির্ভর করে না।

স্বীকার্যগুলোর ব্যাখ্যা

Michelson-Morley's Experiment :



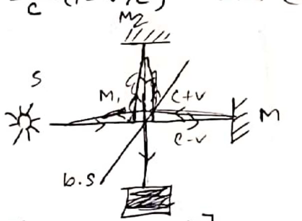
t_1 :

$MM_1M \quad t_1 = \frac{d}{c+v} + \frac{d}{c-v}$

$= \frac{2dc}{c^2-v^2} = \frac{2dc}{c^2(1-v^2/c^2)}$

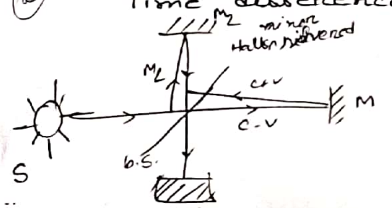
$= \frac{2d}{c}(1-v^2/c^2)^{-1}$ ——— (i)

$MM_2M, \quad t_2 = \frac{2d}{\sqrt{c^2-v^2}} = \frac{2d}{c(1-v^2/c^2)^{1/2}} = \frac{2d}{c}(1-v^2/c^2)^{-1/2}$ --- (2)



Relativity

Time difference $\Delta t = t_1 \sim t_2$



$= \frac{2d}{c}\left[(1-v^2/c^2)^{-1} - (1-v^2/c^2)^{-1/2}\right]$

$= \frac{2d}{c}\left[\left\{1 + 1\cdot 1!\left(\frac{v^2}{c^2}\right) + \cdots\right\} - \left\{1 + \frac{1}{2}\cdot 1!\frac{v^2}{c^2} + \cdots\right\}\right]$

$= \frac{2d}{c}\cdot\frac{1}{2}\cdot\frac{v^2}{c^2} = \frac{dv^2}{c^3}$ — (3)

90°

Fringe Shift, $\Delta N = \frac{2\Delta t}{T} = \frac{2\Delta t \cdot c}{\lambda} = 2\cdot\frac{dv^2}{c^3}\cdot\frac{c}{\lambda}$

Time period

Assumption ছিল

$d = 11 m$, $\lambda = 5.2\times10^{-7} m$, $\frac{v}{c} = 10^{-4}$

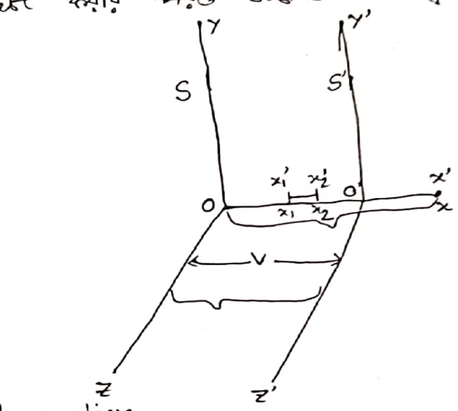
After replacing,

$\Delta N = \frac{2d}{\lambda}\left(\frac{c^2}{v^2}\right)$

$= 0.4$

Practically result পাওয়া যায়নি। যেহেতু Fringe পায়নি সুতরাং light তার সাথে Fringe ও পায়নি। এর Path এ কোনো পার্থক্য হয়নি। অর্থাৎ 2nd postulates সত্য। প্রকৃতপক্ষে light এর velocity constant এবং এটি source এবং observer এর relative position এর উপর depend করেনা। তাই 90° shift করার পরেও fringe তৈরি হয়না।

02-08-2019



Galileam Transformation

i) $x' = x - vt$ $\Rightarrow x = x' + vt$

~~x=ct~~

ii) $y' = y$

iii) $z' = z$

iv) $t' = t$

Lorentz transformation

$t = t' = 0$

$x = ct$ ——— (1)

$x' = ct'$ ——— (2)

$x' = K(x - vt)$ - - - (3)

$x = K(x' + vt')$ ——— (4)

From (3)

$x' = K\,(Kx' + Kvt' - vt)$

$= K^2 x^2 + K^2 vt' - vt$

From (4)

$\cancel{x = K}$

$\Rightarrow t' = \dfrac{x' - K^2 x^2 + vt}{K^2 v}$

From (4),

$x = K\left(x' + \dfrac{x' - K^2 x^2 + vt}{K^2}\right)$

$\Rightarrow \quad = \dfrac{K^2 x' + x' - K^2 x^2 + vt}{K^2}$

$K = \dfrac{1}{\sqrt{1 - v^2/c^2}}$

$x' = \dfrac{x - vt}{\sqrt{1 - v^2/c^2}}$

$y' = y \qquad z' = z$

$t' = \dfrac{t - \frac{vx}{c^2}}{\sqrt{1 - v^2/c^2}}$

Inverse Lorentz Transformation

$x = \dfrac{x' + vt'}{\sqrt{1 - v^2/c^2}}$

$y = y' \qquad z = z'$

$t = \dfrac{t' + \frac{vx'}{c^2}}{\sqrt{1 - v^2/c^2}}$

Space/Length contraction

$S, \quad L_0 = x_2 - x_1$ ——— (1)

$S' \quad L = x_2' - x_1'$ ——— (2)

$L_0 = \dfrac{x_2' + vt'}{\sqrt{1 - v^2/c^2}} - \dfrac{x_1' + vt'}{\sqrt{1 - v^2/c^2}}$

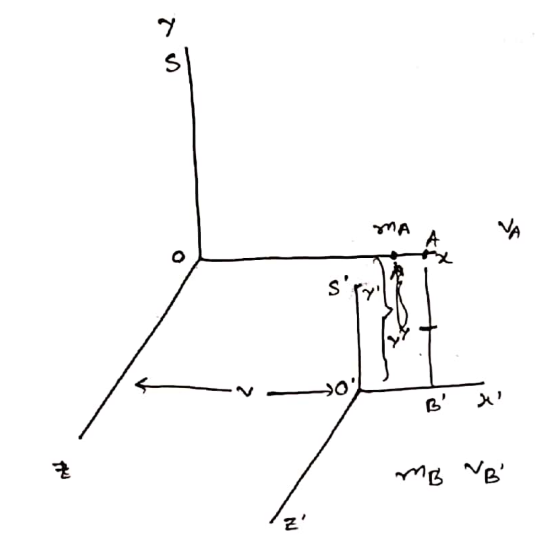
$= \dfrac{x_2' - x_1'}{\sqrt{1 - v^2/c^2}} = \dfrac{L}{\sqrt{1 - v^2/c^2}}$

Time Dilation

$S_1' \quad t_0 = t_1' - t_2'$ - - - (1)

$S \quad t = t_1 - t_2$ ——— (2)

$t = \dfrac{t_1' + \frac{vx'}{c^2}}{\sqrt{1 - v^2/c^2}} - \dfrac{t_2' + \frac{vx'}{c^2}}{\sqrt{1 - v^2/c^2}} = \dfrac{t_1' - t_2'}{\sqrt{1 - v^2/c^2}} = \dfrac{t_0}{\sqrt{1 - v^2/c^2}}$



$S,\ T_0 = \frac{Y}{V_A}$ — (1) $m_A = m_B$

$S',\ T = \frac{Y}{V_{B'}}$ — (2)

$m_A V_A = m_B' V_B'$

$\therefore m_A \cdot \frac{Y}{T_0} = m_B' \frac{Y}{T_0}$

$m_A' = \frac{Y}{T_0} = m_B'$

$m_A = m_B' \sqrt{1 - \frac{v^2}{c^2}}$

$m_B' = \frac{m_A}{\sqrt{1 - v^2/c^2}}$

$m_A = M_0$

$M_B' = m$

$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}$

F ds

$T = \int F \cdot ds = \int^{mv} \frac{d}{dt}(mv)\, ds = \int^{mv} \frac{d}{dt}(mv) \cdot v\,dt$

$\frac{ds}{dt} = v$

$ds = v\,dt$

$= \int^{mv} v\,d(mv) = \int^{mv} v\,(m\,dv + v\,dm)$

$= \int^{mv} (mv\,dv + v^2 dm)$ — —

$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}$

$\Rightarrow 1 - \frac{v^2}{c^2} = \frac{m_0^2}{m^2}$

$\Rightarrow m^2c^2 - m^2v^2 = m_0^2c^2$

$\Rightarrow \cancel{2m}\,dm\,c^2 - \cancel{2m}\,dm \cdot v^2 - \cancel{m^2}\,\cancel{2}v \cdot dv = 0$

$\Rightarrow c^2 dm = v^2 dm + mv\,dv = 0$

$\int_{m_0}^{m} mc^2 - m_0c^2$

$\frac{d(m^2c^2)}{d(mv)}$

$\int_{m_0}^{m} c^2 dm$

$\frac{d(mc^2)}{dm} = \cancel{2mc^2}$ $\frac{d(mv)}{dm} = v$

$K.E = c^2 [m]_{m_0}^{m} = mc^2 - m_0c^2$

$K.E = E - m_0c^2 \quad \therefore E = K.E + m_0c^2$

09-09-2018

Nomenclature

Nuclei

Nuclear physics

$_Z X^A \;|\; (X)^{\underline{A}}_{\underline{\underline{Z}}}$

A = mass no.

Z = No. of proton : Atomic no,

$N = A - Z$

$\boxed{2.8563}$ amu

Mass no.

Mass

<u>Nuclei</u> : X^A_Z , Y^A_Z

Nuclide

Isotopes

Isobar

Isotone

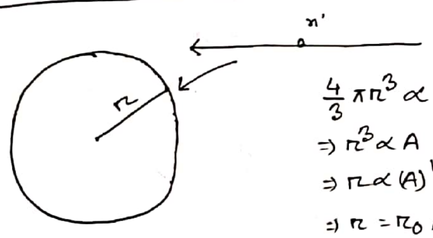
Isomar

<u>Mirror Nuclei</u>

$_3 B_i^7$ $\quad$ $_4 Li^7$

$Z=3, N=4$ $\quad$ $Z=4, N=3$

<u>Nuclear Radius, r</u>



$\frac{4}{3}\pi r^3 \propto A$

$\Rightarrow r^3 \propto A$

$\Rightarrow r \propto (A)^{1/3}$

$\Rightarrow r = r_0 A^{1/3}$

r_0 = 1.3×10^{-15} m = 1.3 fermi

Neuclear density, ρ_N

$\rho_N = \frac{\text{N. mass}}{\text{N. volume}} = \frac{A \cdot M_m}{\frac{4}{3}\pi r_0^3 A} = \frac{M_N}{\frac{4}{3}\pi r_0^3 \cdot A}$

$\Rightarrow$ N. Mass = $A \cdot M_m$

$\frac{4}{3}\pi r^3 = \frac{4}{3}\pi r_0^3 A$

Nue <u>N. Force</u>

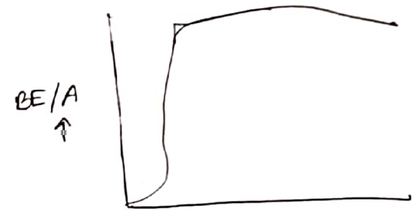
<u>Mass Defect, ΔM</u>

Binding Engergy : BE. বন্ধন

নিউট্রন থেকে নিউক্লিয়াসের বন্ধন ভাঙতে এবং তৈরি করতে যে energy লাগে

মোটের Binding energy

Average Binding Energy



The direction in which it is possible to gain about a change in the structure of nuclide by ~~nuclei~~ bombard with 1st moving particle. As a result, the identity or characteristic or energy or both of ~~the~~ struck particle is known as the nuclear reaction

Nuclear reaction

1st particle

Target nuclei

$a + X \Rightarrow X + a$

$\Rightarrow X^* + a$

$\Rightarrow Y + \text{energy}$

$\Rightarrow Y + b \rightarrow$ 1st particle

${}_7N^{14} + {}_2He^4$

$a + X = Y + b$

$\Rightarrow X(a, b)Y$

$${}_7N^{17} + \underset{\alpha}{{}_2He^4} \Rightarrow {}_8O^{17} + {}_1H^1$$

$$\Rightarrow {}_7N^{14}({}_2He^4, {}_1H^1)_8O^{17}$$

α, β

1) Elastic reaction
2) Inelastic "
   - Exothermic Reaction
   - Endothermic "

Q : Value of nucleonism(NR) : Kinetic energy difference of incident particle and product particle

$K.E = \frac{1}{2} mv$ $\quad$ $P.E = m_0c^2$

$a + X \Rightarrow Y + b$

$E_a + m_ac^2 + (0 + m_xc^2) \Rightarrow (E_y + M_yc^2) + (E_b + m_bc^2)$

or, $(E_y + E_b) - E_a = \cancel{[(m_a + m_x)} \; [(m_a + m_x) - (m_y + m_b)]c^2$

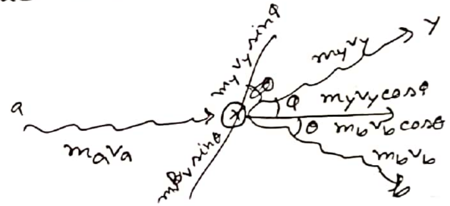
$= \Delta mc^2$

$Q = (E_y + E_b) - E_a$

Significance of Q value of N.R

1) $Q(+ve) / Q > 0 \Rightarrow$ Exothermic reaction
2) $Q(-ve) / Q < 0 \Rightarrow$ Endothermic reaction
3) $Q = 0 \Rightarrow$ Elastic

* Q value with the help of mass-velocity conservative line:



In x direction, $m_av_a = m_yv_y\cos\phi + m_bv_b\cos\theta$ ——(1)

In y " , $0 = m_bv_b\sin\theta - m_yv_y\sin\phi$ ——(2)

From (1), $m_yv_y\cos\phi = m_av_a - m_bv_b\cos\theta$ ——(3)

From (2), $m_yv_y\sin\phi = m_bv_b\sin\theta$ ——(4)

$m_y^2v_y^2(\sin^2\phi + \cos^2\phi) = m_a^2v_a^2 - 2m_am_bv_av_b\cos\theta + m_b^2v_b^2(\cos^2\theta + \sin^2\theta)$

$= m_a^2v_a^2 - 2m_am_bv_av_b\cos\theta + m_b^2v_b^2$

$E_a = \frac{1}{2}m_av_a^2$

or, $V_a^2 = \frac{2E_a}{m_a}$

or, $v_x^2 =$

$v_y^2 =$

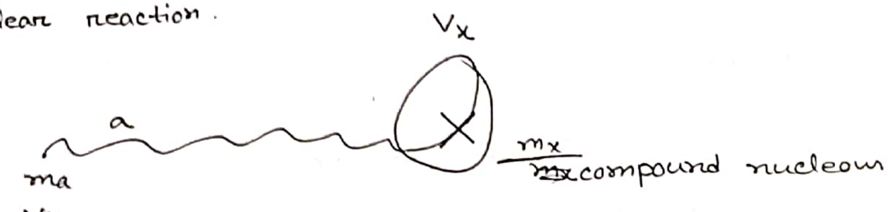
v_b^2

$Q = E_b\left(1 + \frac{m_b}{m_y}\right) - E_a \cdot \left(1 - \frac{m_a}{m_y}\right)$

24-09-2019

Threshold Energy, E_{th} of N.R.
$\downarrow$
N

" " is the minimum energy which is required for nuclear reaction.



Intermediate state of nucleous.

LP

Stable হলে, $V_x = 0$

Compound nucleus -Array তে যেতে nucleous এ incident হয়

$m_2 = m_a + m_x$

$v_c =$

$m_a v_a = m_c v_c$

$v_c = \frac{m_a v_a}{m_c} = \left(\frac{m_a}{m_a + m_x}\right) v_a$

$Q = \underbrace{E_y + E_b}_{E_e} - E_a$

$= E_e - E_a$

$-Q = E_a - E_c$

$= \frac{1}{2} m_a v_a^2 - \frac{1}{2} m_c v_c^2$

$= \frac{1}{2} m_a v_a^2 - \frac{1}{2}(m_a + m_x)\left(\frac{m_a}{m_a + m_x}\right)^2 v_a^2$

$= \frac{1}{2} m_a v_a^2 - \frac{1}{2} m_a v_a^2 \left(\frac{m_a}{m_a + m_x}\right)$

$= \underbrace{\frac{1}{2} m_a v_a^2}_{E_{th}} \left(1 - \frac{m_a}{m_a + m_x}\right)$

$\Rightarrow E_{th} = -Q\left(\frac{m_a + m_x}{m_x}\right)$

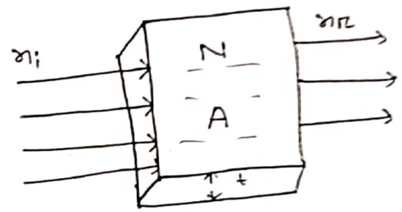
$$\boxed{E_{th} = -Q\left(1 + \frac{m_a}{m_x}\right)}$$

$m_a = 0$ হলে $E_{th} = -Q$

Cross section of N.R.G.

Exposing area of the reactant

Exposing area $\xrightarrow{a}$ C (x)



$\frac{n_r}{n_i} = \frac{GNAt}{A}$ A → Area of the sheet

$= GNt$

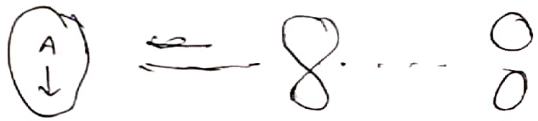
$\Rightarrow G = \frac{n_r}{n_i} \times \frac{1}{nt}$

Nuclear briction

${}_0n^1 + {}_{92}U^{235} \longrightarrow {}_{40}Zn + {}_{52}Te^{135} + 3\,{}_0n^1 + \text{Energy}$

Liquid Drop model:

${}_0n^1 \longrightarrow {}_{92}U^{235} \longrightarrow$

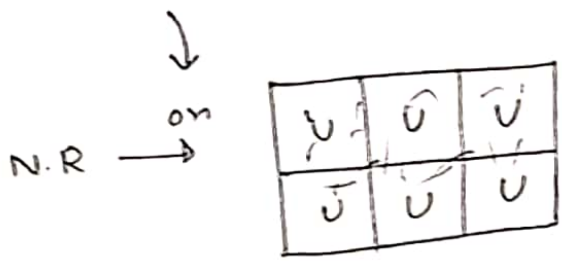


D - day –

Chain Reaction

1) Uncontrolled chain Reaction

2) Controlled " "



neutron একটি first particle

এ বিরলের পদার্থ থাকে যাতে first particle এর velocity কমে যায়।

Cd neutron গুলোকে absorb করবে

এর পর

nuclear physics

Relativity ও তারপর CT

01-10-2019

Radioactivity

1) ~~Radioactivity~~ Natural Radioactivity

2) Artificial "

01.10.19

Radioactivity: The process of disintegration of the material by giving ~~of~~ out the α, β, γ radiation.

দুই ধরনের Radioactivity:

1) Natural radioactivity

2) Artificia radioactivity

The process of ~~continuous~~ spontaneous by its disintegrated of heavy material by giving out the α, β, γ radiation.

The process of artificial disintegration of the lighter nucleus by giving out α, β, γ ray.

Characteristics of radioactive materials:

① Atomic number 82 or more than 82; mass number 206 or more than 206.

② এরা spontaneously disintegrate করে.

③ disintegrate করার পর new material তৈরী করে

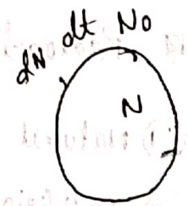
④ এই Process চলার সময় বাইরের external কোনো force বা temperature দ্বারা control করা সম্ভব নয়.

⑤ এদের material α, β, γ radiate করে।

⑥ Rate of disintigration of the substance at any instant is proportion to the number of atoms present at that time.

Radioactive decay / Disintigration Law :

6 নং Point হচ্ছে law.



$\frac{dN}{dt} \propto N$.

or, $\frac{dN}{dt} = -\lambda N$. —— ④

$\Rightarrow$ ~~λ =~~

or, $\frac{dN}{N} = -\lambda dt$.

After Integration,

$\ln N = -\lambda t + C$ —— ②.

If $t = 0$, $N = N_0$.

$\ln N_0 = C$ —— ③.

From equation ② & ③,

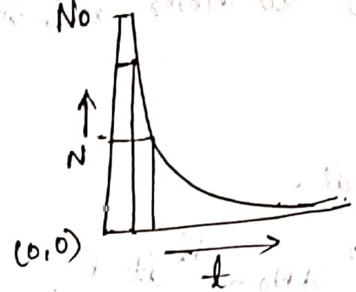
$\ln N = -\lambda t + \ln N_0$.

or, $\ln\left(\frac{N}{N_0}\right) = -\lambda t$

Or, $\frac{N}{N_0} = e^{-\lambda t}$.

Or, $\boxed{N = N_0 e^{-\lambda t}}$.

N_0 → Total number of nucleus.



When, $t = 1/\lambda$.

$N = N_0 e^{-\lambda \cdot \frac{1}{\lambda}}$.

$\frac{N}{N_0} = \frac{1}{e}$

1. Half life time, $T_{1/2}$.

2. Average / Mean life time, τ or T_a or T_m.

Half life এর ক্ষেত্রে, $N = N_0 e^{-\lambda t}$.

$N = \frac{N_0}{2}$

$\frac{N_0}{2} = N_0 e^{-\lambda t_{1/2}}$

$\Rightarrow 2 = e^{\lambda t_{1/2}}$

$\Rightarrow \ln 2 = \lambda T_{1/2}$

$\Rightarrow \boxed{T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}}$

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Mean life time:

ratio of The summation of lifetimes of all atoms and number of total/original atom.

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

$$\tau = \frac{\int_0^\infty -dN.t}{N} = \int_0^\infty \frac{\lambda N_0 e^{-\lambda t}.dt.t}{N_0}$$

$$= \lambda \int_0^\infty t. e^{-\lambda t}. dt.$$

$$= \lambda \left[\frac{t e^{-\lambda t}}{-\lambda} - \int \frac{e^{-\lambda t}}{-\lambda} dt \right]$$

tivity
leus

$$T_a = -\left[\frac{1}{\lambda} (\lambda t + 1) e^{-\lambda t} \right]_0^\infty$$

$$= \frac{1}{\lambda}(0-1) = \frac{1}{\lambda}.$$

Radioactive Equilibrium

Activity : Rate of disintegration is radio activity.

$$A = \frac{dN}{dt} = -\lambda N$$

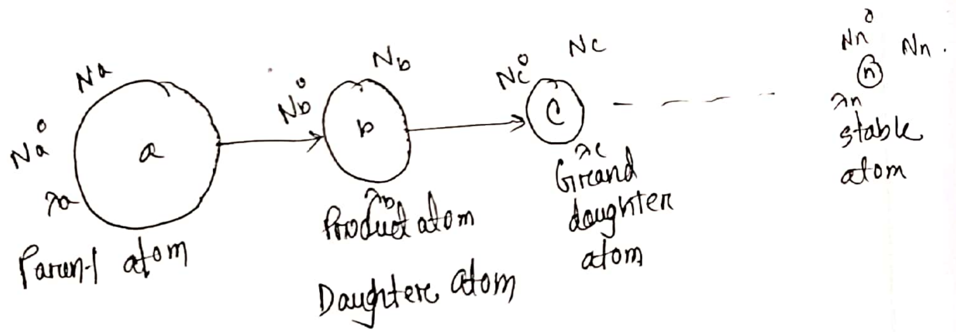
when, $t = 0$, $A_0 = -\lambda N_0$.

$$\frac{A}{A_0} = \frac{-\lambda N}{-\lambda N_0} = \frac{N_0 e^{-\lambda t}}{N_0}$$

$$\therefore \boxed{A = A_0 e^{-\lambda t}}$$

we know, $N = N_0 e^{-\lambda t}$.

Radioactivity equilibrium is a process of radio active material which maintains ~~the rate of~~ equilibrium rate of disintegration of the radio active material between parents and product. ~~atom~~



$$\frac{d(N_b^0)}{dt} = \frac{dN_a}{dt} - \frac{dN_b}{dt}$$

$$= \lambda_a N_a - \lambda_b N_b$$

$$= \lambda_a N_a e^{-\lambda_a t} - \lambda_b N_b$$

$$\frac{dN_b}{dt} + \lambda_b N_b = \lambda_a N_a^0 e^{-\lambda_a t}$$

multiplying by $e^{\lambda_b t}$.

$$\frac{dN_b}{dt} \cdot e^{\lambda_b t} + \lambda_b N_b e^{\lambda_b t} = \lambda_a N_a^0 e^{(\lambda_b - \lambda_a)t}$$

differentiate

or, $\frac{d}{dt}(N_b e^{\lambda_b t}) = \lambda_a N_a^0 e^{(\lambda_b - \lambda_a)t}$

Integration করে

$$N_b e^{\lambda_b t} = \frac{\lambda_a}{\lambda_b - \lambda_a} \cdot N_a^0 \cdot e^{(\lambda_b - \lambda_a)t} + C \quad \text{(1)}$$

$$\cancel{N_b = \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 \left[1 - e^{-\lambda_a t}\right] \cdot e^{-\lambda_a t}}$$

$t = 0$, $N_b = 0$.

$$\therefore C = -\frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 \quad (*)$$

$$N_b e^{\lambda_b t} = \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 \cdot e^{(\lambda_b - \lambda_a)t} - \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 .$$

or, $N_b e^{\lambda_b t} = \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 \left[e^{(\lambda_b - \lambda_a)t} - 1\right]$

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$$N_b = \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 \left[e^{-\lambda_a t} - e^{-\lambda_b t} \right]$$

General equation of radioactive equilibrium.

1. Secular Equilibrium, $t_a >> t_b$, $\lambda_b >> \lambda_a$
2. Transient Equilibrium, $t_a > t_b$, $\lambda_b > \lambda_a$

general equation এ আছে.

এই condition

$$N_b = \frac{\lambda_a}{\lambda_b} N_a^0 \cdot e^{-\lambda_a t} = \frac{\lambda_a}{\lambda_b} N_a$$

or, $\lambda_a N_a = \lambda_b N_b = \lambda_c N_c = \ldots \lambda_n N_n$

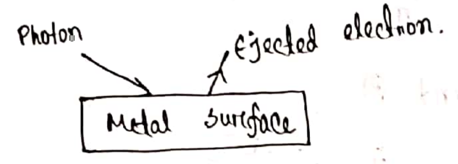
2. Transient Equilibrium:

$$N_b = \frac{\lambda_a}{\lambda_b - \lambda_a} N_a^0 e^{-\lambda_a t}$$

or, $\lambda_a N_a = (\lambda_b - \lambda_a) N_b = (\lambda_c - \lambda_b) N_c = \ldots (\lambda_n - \lambda_{n-1}) N_n$

22.10.19

Photoelectric Effect.



$E_0 = \Phi_0 = h\nu_0$

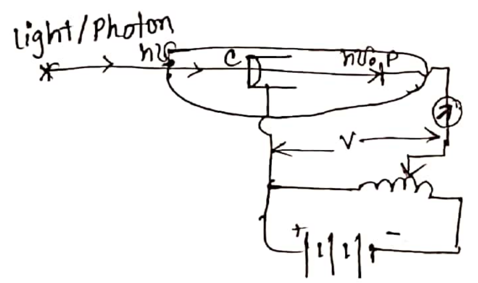
Photoelectric laws :

1. $h\nu = h\nu_0$

2.

3.

Millikan's experiment:



Stopping Potential : V_0.

(Definition)

আইনস্টাইন Photo electric equation:
$h\nu - h\nu_0$ = kinetic energy

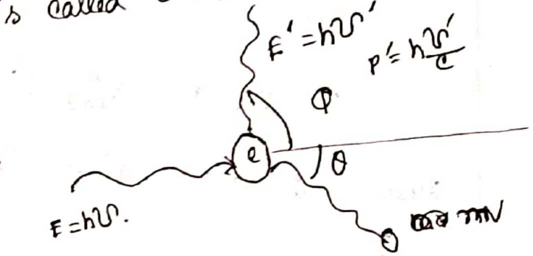
$= \frac{1}{2} m v_0^2$

$= eV_0$

$\boxed{h\nu - h\nu_0 = eV_0}$ Einstein photoelectric equation.

Compton's effect

A reduction of energy of photon, x-rays, γ-rays, β-rays when the scatter by the free electron, this reduction of energy ~~of photo~~ is called compton's effect.



Loss in incidental energy = Gain in electron energy.

$h\nu - h\nu_0' = mc^2 - m_0c^2$.

$= \frac{m_0c^2}{\sqrt{1 - v^2/c^2}} - m_0c^2$.

$= m_0c^2 \left[\frac{1}{\sqrt{1 - v^2/c^2}} - 1\right]$ —— (1).

In x-direction,

Initial momentum = Final momentum.

$\frac{h\nu}{c} + 0 = \frac{h\nu'}{c} \cos\Phi + mv \cos\theta$. —— (2).

In y- direction,

Initial momentum = Final momentum.

$$0 = \frac{h\nu'}{c}\sin\phi - \frac{m_0 v}{\sqrt{1-v^2/c^2}}\sin\theta \quad \text{---} (3)$$

$$\beta = v/c$$

$$\lambda = \frac{c}{\nu}$$

$$\lambda' - \lambda = \frac{h}{m_0 c}(1-\cos\theta).$$

when, $\theta = 90^\circ$. $\lambda' - \lambda = h/m_0 c$. তাকে Compton wavelength হবে।

$\lambda' > \lambda$., এখানে frequency কম হয় এখানে loss Energy কম হয়।

Bohr atom model পড়তে হবে।

Nucleide: If the number of proton and the number of neutron of two nucleous is equal then they included the same nuclear species. This nuclear species is called nucleide.

Isotope: The atoms of an element which have the same atomic number but different mass number are called isotope.

Isotone: The atoms of an element which have the same number of neutrons but different atomic number and atomic masses are called isotones.

Isober: The atoms which have the same mass number but different atomic numbers are called isober.

Isomer: If the two nucleus of same species are in two different energy level and at least if one of them is metastable then they are called isomer.

Special Theory: It concerns with objects and system which are either moving with constant speed with one another.

General Theory: It deals with objects and system which are either accelerating or decelerating with respect to one another.

Nuclear radius: The distance between the centre of the nucleous and its perimeter is called nuclear radius.

Binding energy: Binding energy is defined as the equivalent energy of the mass defect.