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Energy spectrum observation of β-particles

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Abstract:

The aim of this experiment was to become familiarized with scintillation detector and to study the properties of β-particles by observing energy spectrum and determining the range of a beam of β-particles, by using the crystal of sodium iodide detector. Tow sources $^{137}C_s$ and the ^{22}Na were used as gamma ray. The full energy peaks were calibrated by using MAC, characterisation of the detector were carried out and it was found the new β- spectrum was acquired, and Iodine was presented as ^{128}I . From the experimental data was recorded to plot the graph of log (CT) versus time to determinate the decay of ʎ was ( ) from this value to calculate the half life of ^{128}I and determined the half life of ^{128}I to be () and end point energy of the beta spectrum was estimated was (2.1MeV).In the second part of this experiment was used the $^{90}S_r$ and $^{60}C_o$ sources by using difference thickness, to calculated the range and half value thickness of β-particles. The measured value was then compared to a value derived using the empirical formulas which can be used to derive of β-particles range in deferent absorbers

Keywords- beta particles- total absorption spectrum -$^{90}S_r$ and $^{60}C_o$ sources- sodium iodide detector

الملخص:

كان الهدف من هذه التجربة هو التعرف على كاشف التلألؤ ودراسة خواص جسيمات بيتا من خلال مراقبة طيف الطاقة وتحديد مدى شعاع جسيمات بيتا باستخدام بلورة كاشف يوديد الصوديوم. تم استخدام مصدرين Cs 137 و22 Naكأشعة جاما. تمت معايرة قمم الطاقة الكاملة باستخدامMAC ، وتم إجراء توصيف الكاشف وتبين أنه تم الحصول على طيف بيتا الجديد، وتم تقديم اليود كـ 128 I. من البيانات التجريبية تم تسجيل رسم الرسم البياني للسجل (CT) مقابل الوقت لتحديد انحطاط ʎ كان () من هذه القيمة لحساب نصف عمر 128 I وتحديد نصف عمر 128 I ليكون () و تم تقدير طاقة نقطة النهاية لطيف بيتا بـ (2.1 MeV).في الجزء الثاني من هذه التجربة تم استخدام مصادر 90 Sr و 60 Coباستخدام فرق السماكة لحساب المدى ونصف القيمة لسمك جسيمات بيتا. تمت بعد ذلك مقارنة القيمة المقاسة بالقيمة المشتقة باستخدام الصيغ التجريبية التي يمكن استخدامها لاشتقاق نطاق جسيمات بيتا في المواد الماصة المختلفة.

الكلمات المفتاحية – جسيمات بيتا – طيف الامتصاص الكلي – مصادر كاشف يوديد الصوديوم

Introduction:

The ordinary source of fast electrons from the nucleus transformation of a proton to a neutron or of neutron into proton. The beta decay process as produce as nuclear component, which process electron from the accessible decay energy at the instant of decay. Then the electron instantly expel from the nucleus, this position compares with α- decay in which α particle probably observed is having a previous presence in the nucleus. The basic decay processes are thus:

$$n \rightarrow p + {}^{-}e \text{ negative } \beta \text{ decay}(\beta^{-})$$

$$p \rightarrow n + {}^{+}e \text{ positive beta decay}(\beta^{+})$$

$$p + {}^{-}e \rightarrow n \text{ orbital electron capture } (\varepsilon)$$

The radioactive nuclides move towards stability by increasing or decreasing or decreasing the nuclear charge through beta decay (β^{-}, β^{+}) or electron capture. These are two reactions with conservation of energy and momentum laws.

Continues distribution of energies for β particles from zero to the endpoint energy, which is equal to primary and final stats. Each specific beta decay transition is characterized by fixed decay energy. Most beta decay emitters produce Gamma ray form the excited daughter nuclear.

The aim of the experiment to investigate the spectrum of beta decay, and calculate the endpoint and half life of beta particle emitter ^{128}I. Moreover, to study the absorption properties of beta decay by aluminium and to determine the half –value thickness and rang of beta decay emitted from different sources whit different energies.

1- Brief theory :

The ionization and electron excitation is absorbed from in the reaction between the electric fields of a β particle and electrons. The electrical forces are kept the electron in the atom and energy is lost by β particle in overcoming these forces. Moreover beta decay the change in binding energy appears as the mass and kinetic energy of the beta particle. The energy of the neutrino and the kinetic energy of the recoiling.

Therefore, it is relatively complex to determine the range of beam of a beam of β-particle may emit Bremsstrahlung radiation. These photons probably able to Carrey a larger distance through the absorber than typical β- particle.

These relate the β-particle end energy, E, to the maximum range, R. A typical empirical relationship that holds when E>0.8 MeV and R >0.3 g/cm^2 is

$$R= (0.542\times E)-0.133 \qquad (1)$$

Where R is expressed in g/m^2 and E in Mev.

At lower energies (E<0.8Mev) ionisation losses and elastic scattering are more significations. When E <0. 8 Mev and R<0.3g/cm^2 is

$$R=0.407\times E^{1.38} \qquad (2)$$

Finally, to calculate the half value thickness ($t_{1/2}$) the following equation can be used:

$$t_{1/2} = 0.046\times E^{2/3}\ g/cm^2 \qquad (3)$$

3- Experimental Methods and Equipments:

1-Experiment Equipments: The sodium iodide Nal (Te) was connected to the preamplifier and photomultiplier, from there to a shaping amplifier, HV supply.

2- Experiment Method: At the beginning a calibration was carried out for the system, by pleasing $^{137}C_s$ source a few centimetres away from the crystal and the gamma peak was appeared clearly. The Hv was adjusted to (580V), the full energy peak $^{137}C_s$ was recorded to be (662 kev-γ ray) is located to approximately (1/3) full scale. Then the $^{137}C_s$ sour ce was replaced the ^{22}Na, which measured tow beaks, the energy of these peaks were (511kev annihilation photon and 1274 kev – γ ray). Then the HV was turn off to zero volts. The NaL (TL) crystal was dismantled from the photomultiplier tube by laboratory supervisor, to lowered in to the Am/Be neutron source which was located in the waterproof bag, the NaL(TL) crystal was leaved under irradiation for 10 minutes. Here the Iodine is presented as ^{127}I which was non radio activate to transfer to the ^{128}I is a β – emitter. Finally, the crystal from the Am/Be tank was removed and reassemble it which the photomultiplier tube, and connect the detector for beak to it electronics, then turn the HV was to (580v).

The previous data was reseeded before the MAC is set to acquire a new spectrum and the cursor into the channel was positioned to (500kev). The total counts of channel every 60 seconds for life time were recorded until 1800s. Then the graph of log (CT), the data was In this part of the experiment the G-M tube detector was used, the ^{90}Sr source which is β-emitter was placed at the bottom inside the chamber. The count rate recorded without any barrier between the detector and source for 60s; in this case the ^{90}Sr source of β- radiation was obtained with set of Al plates of aluminium for varying thicknesses were located between the detector and source. The data was recorded for 60suntil the count reached background of ^{90}Sr was (40), and the true mass thickness in to account absorption in the air Collected to determine the half life of ^{128}I and the end point energy for ^{128}I.

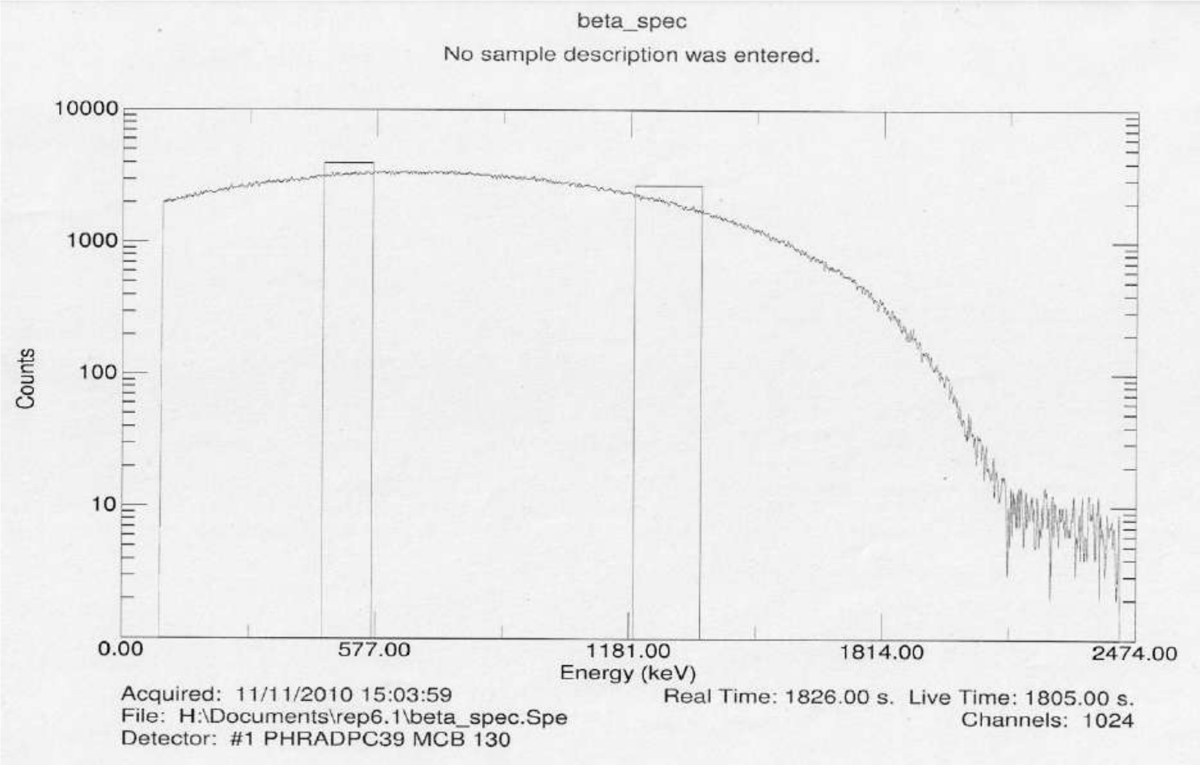
3.2- β –Particles Range:

(Assuming 1.3 mg/cm^2 for each 1 cm path of air) was calculated. Then the graph of count rate versa absorber thickness was plotted. It can see that the ^{90}Sr emits a β- particle with a maximum energy of (0.45Mev) and ^{90}Y the daughter of ^{90}Sr emits of β- particle with maximum energy of 2.25 Mev, Then by using $^{60}C_S$ source that emits tow γ-rays as β-particle, the count rate was recorded for the same thicknesses of aluminium absorber as before. Then the graph of count rate versus absorber thickness was plotted. The second part of this experiment by using ^{90}Sr source with the G-M tube detector in this part using two methods, by placing ^{90}Sr. The first method when the ^{90}Sr was placing on the floor of the lead with absorber close to detector, the count rate varying thickness of observers was recorded. The graph of count rate versus absorbers thickness was plotted. The second methods when the absorbers at the bottom close to the source which is (55mm), changing in thickness was continued until the count. Then the graph of count rate versus absorber thickness was plotted.

4-Result and Discussion:

4.1 β –Particle Spectroscopy:

This section of the experiment is divided in two parts where the sure cess ^{22}Na and $^{137}C_s$ were used by using NaL (Tl) detector with Hv was adjusted (580v.The first part of this section, the figure (1.2) show the β-spectrum and β- γ spectrum obtained by MAC. It shows three peaks which are the full energy peak at (662kev-ɣ -ray) for$^{137}C_S$, and by replacing ^{22}Na source and $^{137}C_s$, the full energy peaks were (511kev annihilation photon and 1274 kev γ-ray) were calibrated. By using the MAC to recalibrate, the end point energy was determent from its position the cursor into the channel corresponding was found to be (2.1 Mev) this value which less than expected value of around (2.2Mv).



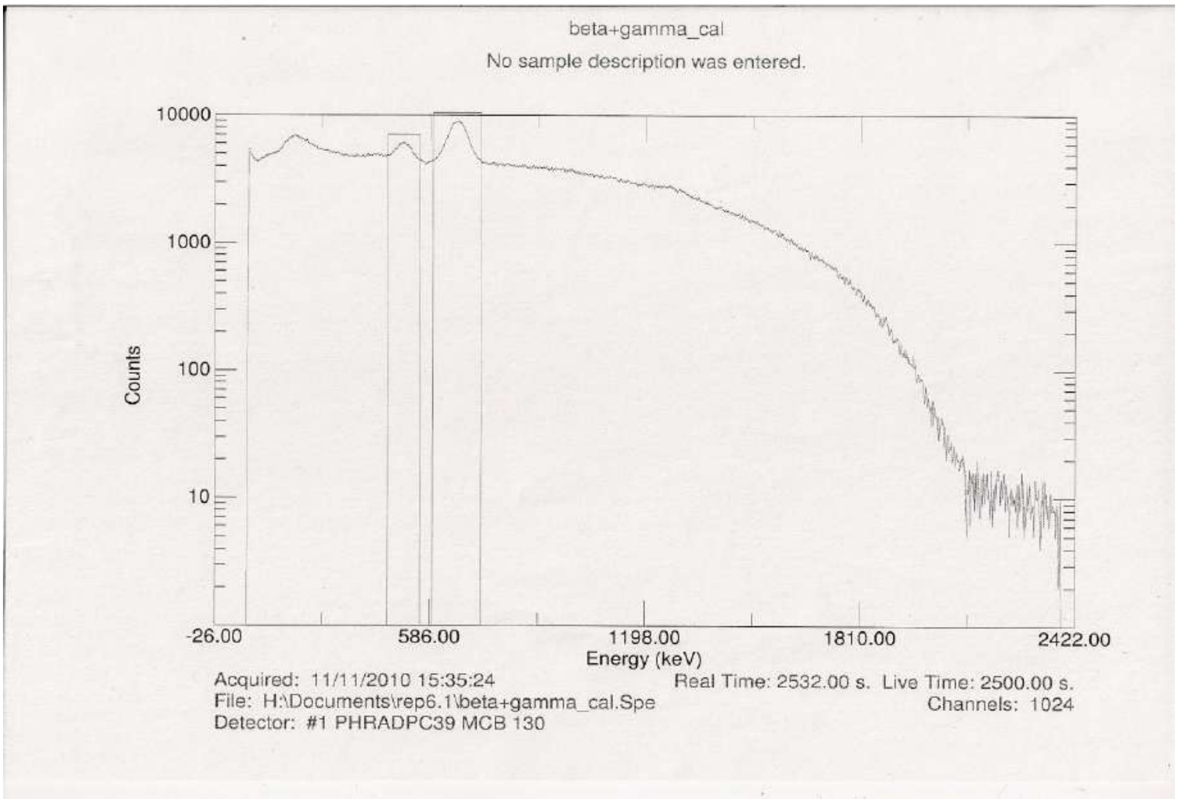


Figure (1,2) Beta- spectrum, Beta-Gamma spectrums

The second part of this experiment, the table (1) shows the time (sec) versus log count/sec of ^{22}Na, ^{137}Cs is determined by MAC.

Time(sec)	Log count/sec
60	0.383217
120	0.393575
180	0.385209
240	0.39911
300	0.39795
360	0.395035
420	0.393784
480	0.386573
540	0.384878
600	0376273
660	0.365431
720	0.362776
780	0356859
840	0.349185
900	0.341764
960	0.338498
960	0.338498
1020	0.331646
1080	0.322411
1140	0.313238
1200	0.308031
1260	0.367238
1320	0.300865
1380	0.295169
1440	0.288796
1500	0.253176
1560	0.279632
1620	0.274357
1680	0.268845
1740	0.26365
1800	0.258345

Table (1) Time (sec) versus Log count/sec

The result obtained from β- particles spectroscopy are show in finger (3).

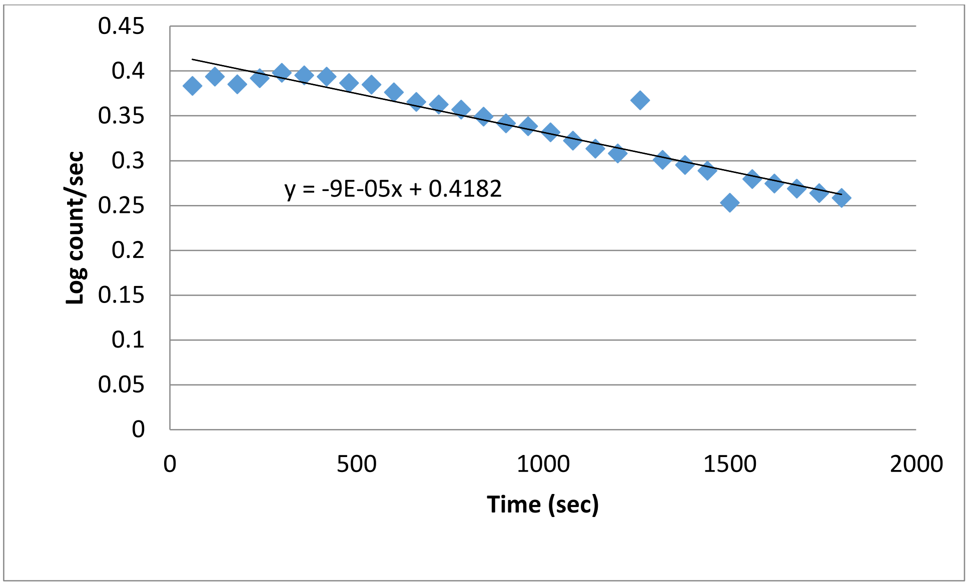


Figure (3) Time (sec)vs Log count/sec

From the plot the graph the decay constant ʎ was calculated was fond to be (), from this value ʎ by using equation of half lifetime to find half life time of ^{128}I,

The half live of ^{128}I is equal to:

$$t_{1/2} = 0.693/ʎ$$

$$^{128}I\ half-life = 0.693/.05 = 13.65s = 23.1mins$$

This value is somewhat different the expected value (25mintes), the different probably deterioration of the Nal(TI;) deterioration

4.2 β-Particles Range:

In this part of the experiment, the figures (4, 5) below show the data a concerning each peak of ^{90}Sr and ^{60}Co sources, the attenuation of beta ray absorber measured by intervening varying thickness of absorbers between a beta ray sours and G.M tube detector, and the counting the beta particle for varying thickness of absorbers was done. It can be seen from the figure (4, 5) that the counting rate decreases speedy at first and then slowly the absorber thickness increase. After that the thickness absorber was reached to stop most of the beta particles that were emitted from source, and then recorded background. As a result, the endpoint in the absorption spectrum, which is the beta particle disappear.

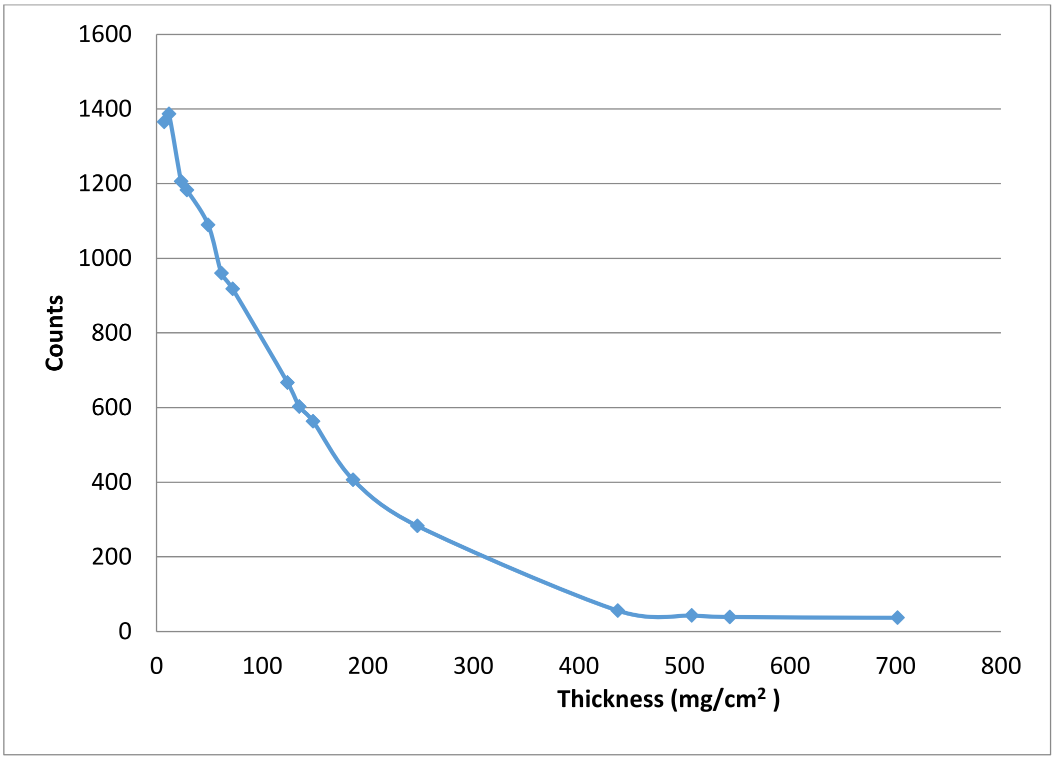


Figure (4) Attenuation spectrum for ^{90}Sr

Also in figure (5) show the ^{90}Cs which was emitted beta particle and gamma rays, it is found the gamma radiation cannot be stopped by similar mass thickness.

The maximum thickness was used to attenuate beta particle was (695mg/cm^2).

Then from the maximum beta-energies were known, by measuring the count rate in different absorbers can be calculated as follows by using equations 1 and 2.

For ^{90}Sr (E< 0.8MEV)

$R = 0.407E^{1.38}$

$= 0.407 \times (0.54)^{1.38}$

$= 0.173899 g/cm^2$

$= 173 mg/cm^2$

For ^{90} Y (E>0.8 Mev)

$R = (0.542 \times E) - 0.133$

$= (0.542 \times 2.25) - 0.133$

$= 1.0865\ g/cm^2$

$= 1086.5\ mg/cm^2$

Similarly,

For ^{60}Cs (E < 0.8 Mev)

$R = 0.407E^{1.38}$

$= 0.407 \times (0.31)^{1.38}$

$= 0.08 g/cm^2$

$= 80.8\ mg/cm^2$

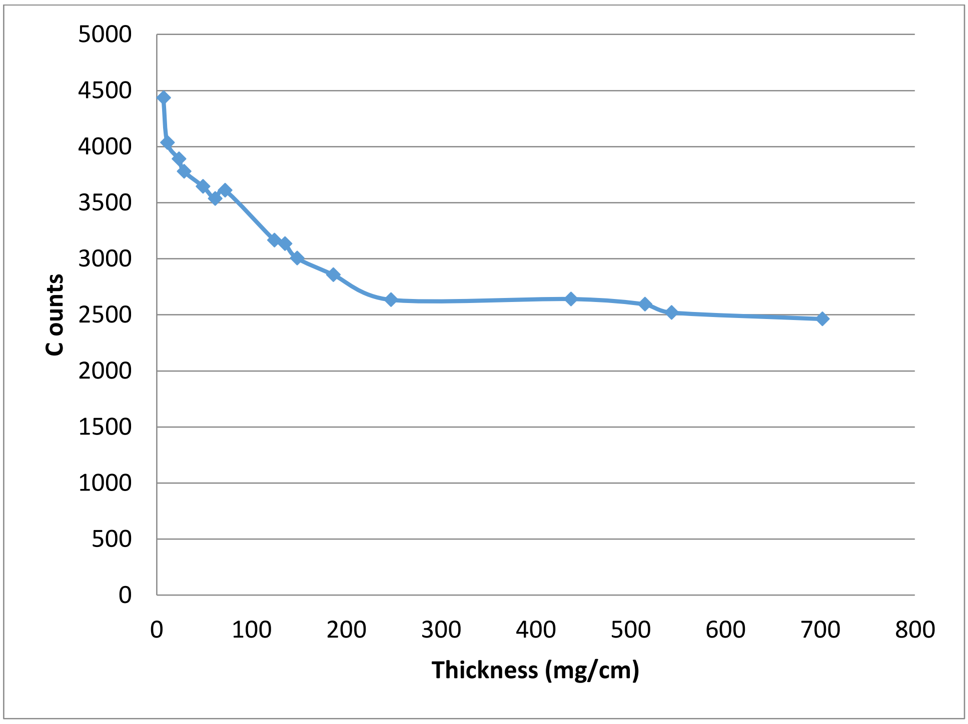


Figure (5) Attenuation spectrum for ^{90}Cs

It found, t range value was calculated from the range spectrum for the beta –particle, which measured in the different thickness. The range value of ^{90}Sr emitted a 0.54 Mev beta particles to be (173mg/cm) and the daughter, ^{90}Y emitted a beta particle whose maximum energy 2.25Mev rang value was (1086.5mg/cm^2). it can see clearly the different between the^{90}Sr and ^{90}Y in comparison with the expectation. as a result, the various energy value of beta particle emitted from ^{90}Sr and ^{90}Y to make it impossible to distinguish between them inside the matter. However, the ^{60}Cs is difficult to determent the endpoint, because the emission of gamma rays.

In this part in the experiment was to demonstrate the effect of the position the absorbers on the measurement of beta –particle. By placing the ^{90}Sr source on the placing the ^{90}Sr source near the G-M tube, then near to the source. It can show tow curves form the graph (6) between the count rate and different thickness, where further decreasing the counting rate is observed.

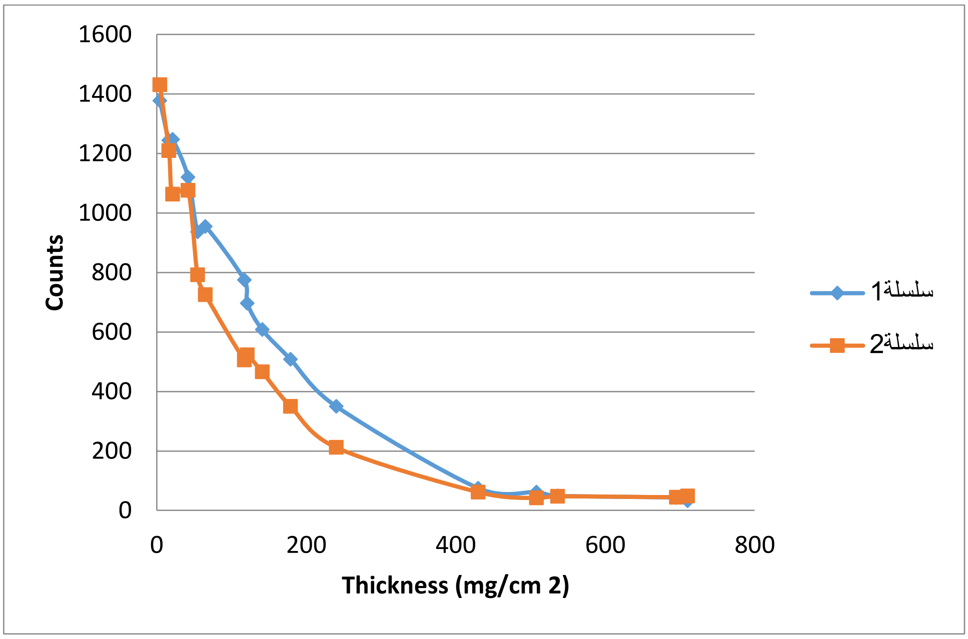


Figure (6) Attenuation spectrum for^{90}Sr at two different position of the absorber

Empirically, the half life value thickness was calculated and found to be:

For ^{90}Sr, $t_{1/2}=0.046\times E^{3/2}$ g/cm^2

$=0.046\times (0.540)^{3/2}= 0.018$g/cm^2

For ^{90}y

For ^{90}Sr, $t_{1/2}=0.046\times E^{3/2}$ g/cm^2

$=0.046\times (2.25)^{3/2}=0.155$

For ^{60}Cs ***r*** ^{90}Sr, $t_{1/2}=0.046\times E^{3/2}$ g/cm^2

$= 0.046\times (0.31)^{3/2}= 0.007$g/cm^2

The half value thickness of ^{90}Sr was found 0.018g/cm ^{2}. However, the^{60}Co was not possible to determine the half thickness, because to present of gamma ray.

Conclusion:

The general features of beta- ray spectrum and the performance characteristics of Nal(TL) scintillate detector and G-M tube detector, have been investigated the collected of beta – ray present, where the energy distribution of emitted beta particles (5) ranges from $E_{\beta=0}$ up to the decay energy E_0 the beta particle counting rate decreases quickly, and the absorber thickness increases. Moreover the half of ^{128}I an emitter of beta particle was determined it found (23.1) min, and the endpoint in the absorption spectrum where no further decrease in the counting rate was (2.1Mev). In addition the maximum beta ray energy for ^{90}Sr, ^{90y} and ^{60}Cs were measured from beta –ray range in deferent absorber it found to be 00.173,1.0865and 0.08 g/cm^2. Also there are the half thicknesses of the absorber of ^{90}Sr; ^{90}Y and ^{60}Co respectively were equal 0.018, 0.155 and 0.007 g/cm^2. There are many possible future experiments that can be carried out with this particles . measurements of the beta distribution provide stringent test of nuclear model calculation. They have been neglected in past because there was no reliable means of measuring such as distributions accurately.(6)

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