Chapter one

Introduction

In this research dealt with atomic structure of mater, and then the beginning of the different links of atoms.

This study contains the atomic bonding divided into ionic bonding, covalent bonding, Metallic Bonding .and standard atomic Wight. In solid the atoms or molecule are bonding in such away. They are broadly classified into two groups namely crystalline solids and amorphous, crystalline solid is better understood physically than amorphous solid .the crystal systems can be classified into many groups. The objective of the present work is to Attenuation of x-ray and How production and properties of x-ray. Also biological effects of x-ray its ionizing radiation absorbed by human tissue have direct and an indirect effect of radiation on cells at the last experiment on the attenuation of x-ray of Aluminum element with difference thickness and the result represented on the curve and in the second case the difference elements with one thickness and the result represented on the curve.

1.1The objectives of the study:

It's the study of the attenuation of X-ray by using different elements and also by different thickness.

1.2Literature Review:

Radiation is energy in the form of waves or particles. Radiation high enough in energy to cause ionization is called ionizing radiation
. It includes particles and rays given off by radioactive material, stars, and high-voltage equipment. Ionizing radiation includes x-rays, gamma-rays, beta particles, alpha particles, and neutrons.

Without the use of monitoring equipment, humans are not able to" detect" ionizing radiation. In contrast to heat, light, food, and noise, humans are not able to see, feel, taste, smell, or hear ionizing radiation [1]

In passing through matter, energy is transferred from the incident x-ray photon to electrons and nuclei in the target material. An electron can be ejected from the atom with the subsequent creation of an ion. The amount of energy lost to the electron is dependent on the energy of the incident photon and the type of material through which it travels. There are three basic methods in which x-rays interact with matter: photoelectric effect, Compton scattering, and pair production.

The probability of photons interacting, especially with the photoelectric effect, is related to the energy. Increasing photon energy generally decreases the probability of interactions (attenuation) and, therefore, increases penetration [1].

As a rule, high-energy photons are more penetrating than low-energy photons, although there are limits and exceptions to this.

When using aluminum sheets together with the protection level thickness, however, results of various ranges were obtained. This type of result helps to plot the attenuation curves in accurate manner which leads to evaluate and calculate 36the values of HVL for each x-ray quality. Though the trends of the curves obtained follows the exponential fits, the values of the HVL were greater than the reference values. Thus the results guided us to establish the standard quality for diagnostic level beside the built-in thickness of protection level. When removing thickness of the protection level (i.e. direct x-ray beams)[1].

1.3Statement of the problem:

Despite the great importance of radiation in medical diagnosis and treatment, but the x-ray substantial damage to cells and thereby destroy cancer when exposed to large doses and also intervention in the treatment of cancer .

1.4 Research layout:

This research consists four chapter, chapter one consist introduction, chapter two consist on Atomic structure of matter, chapter three consist on X-ray , and the last chapter four consist on Experiment.

Chapter Two
Atomic Structure Of Matter

2.1 Background:

Matter can be broken down chemically into elements – H, C F e etc. These consist of atoms, which for many years were regarded as the smallest, indestructible units of matter.

However, in the decade around turn of the 19th century, key discoveries were made which completely changed this view.

From studies of electrical discharges in gases, JJ Thompson in 1897 demonstrated the existence of the electron as a fundamental unit of negative electricity having a very small mass compared with that of an atom. Evidently, the atom could be split into a positively - charged part [a nucleus] and negatively charged electrons.

In 1896, Henri Becquerel in France first encountered radioactivity in the form of unknown radiations emanating from uranium-bearing rocks. Later studies showed there are 3 distinct types of radiation: alpha, beta and gamma rays –terms that have been retained to this day. Later work, notably by Ernest Rutherford in England, showed that alpha particles are positively charged helium nuclei, beta particles are electrons and gamma rays were identified as energetic electromagnetic radiation ([photons) [2].

Rutherford and his co-workers, first in Canada (1898-1907) and later in Manchester England (1907-1919) made detailed studies of the way beams of alpha particles pass through matter. It was noted that occasionally, an alpha particle was scattered backwards by even very thin foils of gold. Rutherford realized that this could only be explained if the alpha particle had encountered a tiny, massive charged entity less than 1/1000th of the atom in size. He proposed the planetary model of the atom as consisting of a small heavy positively-charged nucleus surrounded by orbiting electrons which occupy the vast bulk of the atom's volume. The simplest [lightest] atom, hydrogen, was pictured as an electron orbiting a proton held together by the electrical force

acting between them. Other atoms were thought to be combinations of these two fundamental particles. However, further studies and developments in quantum mechanics exposed several fatal shortcomings to this proton-electron model of the nucleus [2].

All atoms are composed of a central nucleus surrounded by a number of orbiting electrons-like planets orbiting the sun

A problem is that orbiting electrons would be accelerating and should radiate energy causing them to spiral into the nucleus. We will see why they don't later.

An atomic nucleus is the small heavy central part of an atom consisting of A nucleons: Z protons and N neutrons.
A is referred to as the mass number and Z the atomic number.

Nuclear size is measured in fermis (also called femtometres), where $1fm = 10^{-15}$ m [2].

2.2 Unit Cell:

A unit cell is a small parallelepiped crystal lattice to which the lattice structure is subdivided and whose repetitive extension in three dimensions gives rise to the crystal]. It has three sets of parallel faces. A unit cell is chosen to represent the symmetry of the crystal structures, wherein all the basis positions in the crystal may be generated by the translation of these cells placed at integral distances along each of these edges. p Each unit cell is indistinguishable from the next. Thus, unit cell in figure 2.1 is the building block of the crystal structure [3].
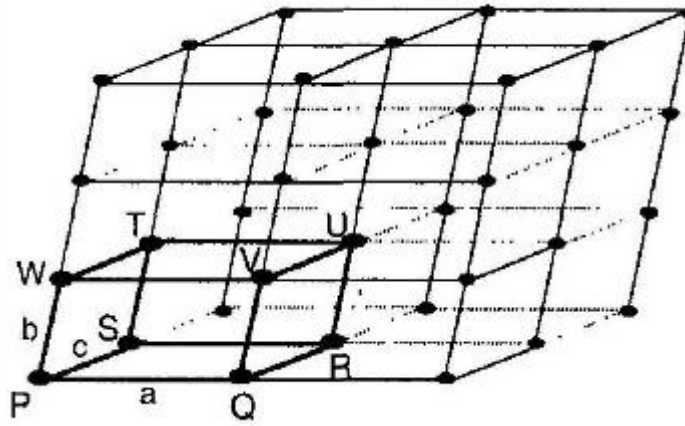
Figure 2.1: unit cell
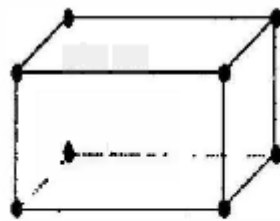
2.3 Crystal System:

The basis vectors of unit cells may or may not be equal. The interfacial angles of unit cells may or may not be right angles. On the basis of the values of these translation parameters, crystals may be classified into seven groups called as basic crystal system. Although, there are thirty-two classes of crystal systems based on geometrical considerations, such as, symmetry and internal structure, it is common

practice to divide all the crystal systems into seven groups only.

This classification is as follows S [4].

2.4 Bravai's Crystal System:

Atoms piled in lattice spaces results in a great many of crystal structures. But, each of the structures consist of some fundamental patterns repeated at each point of a space lattice. The unit cells are built so that they contain lattice elements, not only at their apexes, but at other points as well. Such cells are termed complex cells. The most wide spread types of such cells, apart from simple cells; are (i) body centered (BC), (ii) face centered (FC) and (iii) the base centered (Base C) Cells and their patterns are as shown in figure 2.2 [4]
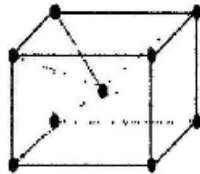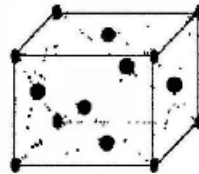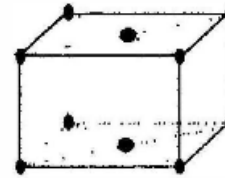
Figure 2.2: crystal system

2.5 Atomic Bonding Solids:

In order to understand the why materials behave like they do and why they differ in properties, it is necessary that one should look at atomic level. The study primarily concentrates on two issues: what made the atoms to cluster together, and how atoms are arranged. As mentioned in earlier chapter, atoms are bound to each other by number of bonds. These inter-atomic bonds are primarily of two kinds: Primary bonds and Secondary bonds. Ionic, Covalent and Metallic bonds are relatively very strong, and grouped as primary bonds, whereas van der Waals and hydrogen bonds are relatively weak, and termed as secondary bonds. Metals and Ceramics are entirely held together by primary bonds - the ionic and covalent bonds in ceramics, and the metallic and covalent bonds in metals. Although much weaker than primary bonds, secondary bonds are still very important. They provide the links between polymer molecules in polyethylene (and other polymers) which make them solids. Without them, water would boil at -80°C, and life as we know it on earth would not exist [5] .

2.5.1 Ionic Bonding:

This bond exists between two atoms when one of the atoms is negative (has an extra electron) and another is positive (has lost an electron). Then there is a strong, direct Coulomb attraction. Basically ionic bonds are non-directional in nature. An example is NaCl. In the molecule, there are more electrons around Cl, forming Cl and fewer electrons around Na, forming Na^+. Ionic bonds are the strongest bonds. In real solids, ionic bonding is usually exists along with covalent bonding as shown figure 2.3 [5].
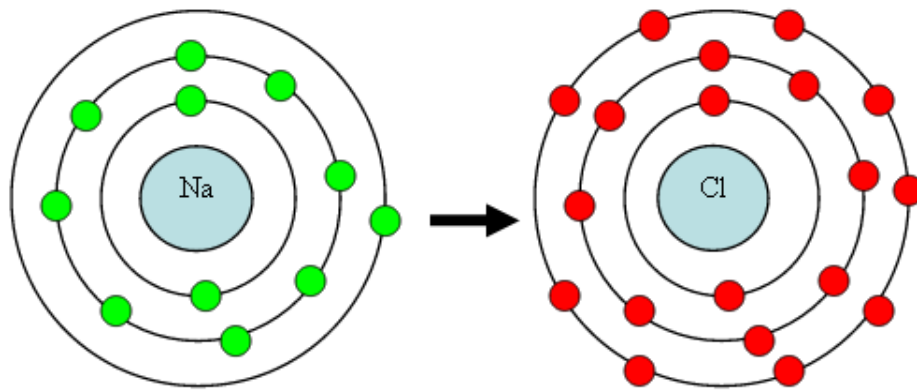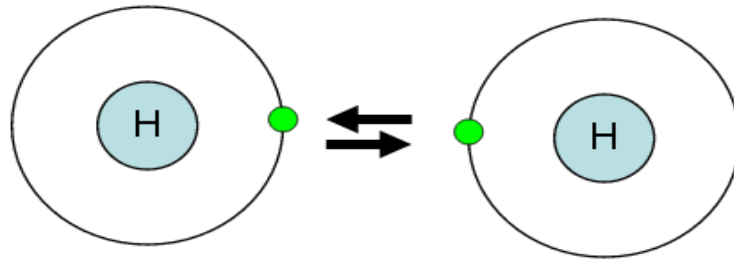

Figure (2-3): Schematic representation of ioning bonding. Here, Na is giving an electron to Cl to have stable structure

2.5.2 Covalent Bonding:

In covalent bonding, electrons are shared between the atoms, to saturate the valiancy. The simplest example is the H_2 molecule, where the electrons spend more time in between the nuclei of two atoms than outside, thus producing bonding.

Covalent bonds are stereo-specific i.e. each bond is between a specific pair of atoms, which share a pair of electrons (of opposite magnetic spins). Typically, covalent bonds are very strong, and directional in nature. The hardness of diamond is a result of the fact that each carbon atom is covalently bonded with four neighboring atoms, and each neighbor is bonded with an equal number of atoms to form a rigid three-dimensional structure [5].

Figure (2-4): Schematic representation of covalent bond in Hydrogen molecule (sharing of electrons)

2.5.3 Metallic Bonding:

Metals are characterized by high thermal and electrical conductivities. Thus, neither covalent nor ionic bonding is realized because both types of bonding localize the valence electrons and preclude conduction.

However, strong bonding does occur in metals. The valence electrons of metals also are delocalized. Thus metallic bonding can be viewed as metal containing a periodic structure of positive ions surrounded by a sea of delocalized electrons. The attraction between the two provides the bond, which is non-directional as shown in figure 2.5 [5].
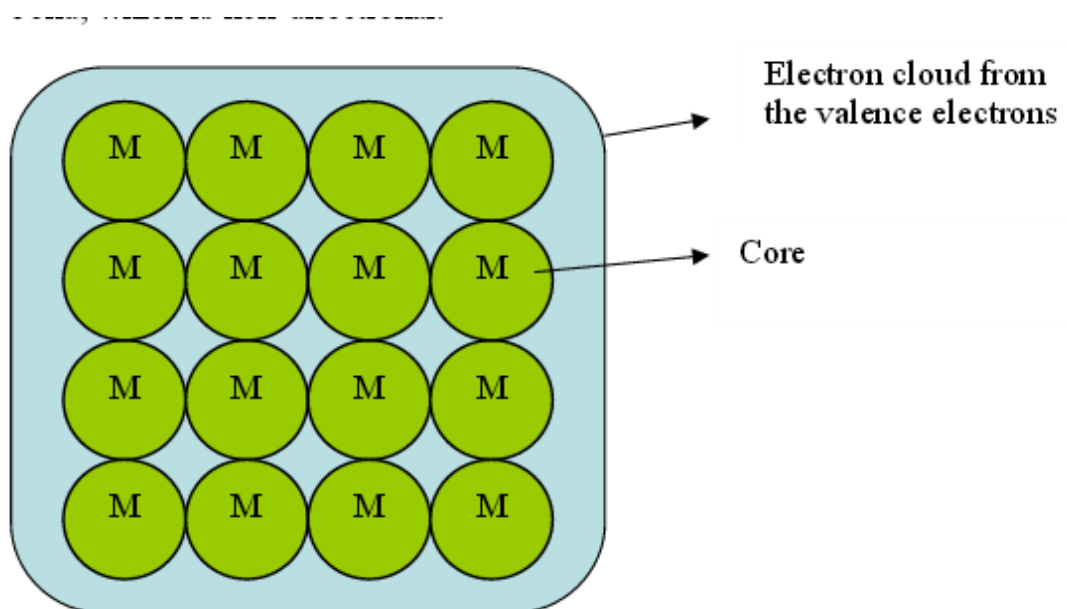
Figure 2.5: Metallic Bonding

2.6 Standard Atomic Weights:

[Scaled to Ar(12C) = 12, where 12C is a neutral atom in its nuclear and electronic ground state.

The atomic weights, Ar(E), of many elements vary because of variations in the abundances of their isotopes in normal materials. For 12 such elements, an atomic-weight interval is given with the symbol [a,] to denote the set of atomic-weight values in normal materials; thus, a≤Ar(E)≤b for element E. The symbols a and b denote the bounds of the interval [a, b]. If a more accurate Ar(E) value for a specific material is required, it should be determined. For 72 elements, Ar(E) values and their evaluated uncertainties (in parentheses, following the last significant digit to which they are attributed) are given. Names of elements with atomic number 113, 115, 117, and 118 are provisional; they have been reported in the peer-reviewed, scientific literature, but they have not yet been named by IUPAC.

Alphabetic order in English Elem beryllium [6] .

Table 2.1: Standard atomic weights 2011[Scaled t Ar(12C) = 12, where 12C is a neutral atom in its nuclear and electronic ground state:

Table 1 (*Continued*).

		Alphabetic order in English			
Element name	Symbol	Atomic number	Standard atomic weight	See also Table/Figure	Footnotes
rubidium	Rb	37	85.4678(3)		g
ruthenium	Ru	44	101.07(2)		g
rutherfordium*	Rf	104			
samarium	Sm	62	150.36(2)		g
scandium	Sc	21	44.955912(6)		
seaborgium*	Sg	106			
selenium	Se	34	78.96(3)		r
silicon	Si	14	[28.084, 28.086]	6/8 in ref. [8]	
silver	Ag	47	107.8682(2)		g
sodium	Na	11	22.989769 28(2)		
strontium	Sr	38	87.62(1)		g r
sulfur	S	16	[32.059, 32.076]	6/9 in ref. [8]	
tantalum	Ta	73	180.947 88(2)		
technetium*	Tc	43			
tellurium	Te	52	127.60(3)		g
terbium	Tb	65	158.925 35(2)		
thallium	Tl	81	[204.382, 204.385]	6/11 in ref. [8]	
thorium*	Th	90	232.03806(2)		g
thulium	Tm	69	168.93421(2)		
tin	Sn	50	118.710(7)		g
titanium	Ti	22	47.867(1)		
tungsten	W	74	183.84(1)		
ununoctium*	Uuo	118			
ununpentium*	Uup	115			
ununtrium*	Uut	113			
ununseptium*	Uus	117			
uranium*	U	92	238.02891(3)		g m
vanadium	V	23	50.9415(1)		
xenon	Xe	54	131.293(6)		g m
ytterbium	Yb	70	173.054(5)		g
yttrium	Y	39	88.905 85(2)		
zinc	Zn	30	65.38(2)		r
zirconium	Zr	40	91.224(2)		g

The atomic weights Ar(E), of many elements vary because of variations in the abundances of their isotopes in normal materials. For 12 such elements, an atomic-weight interval is given with the symbol [a b] to denote the set of atomic-weight values in normal materials; thus, a≤Ar(E) ≤b for element E. The symbols a and b denote the bounds of the interval [a, b]. If a more

accurate Ar(E) value for a specific material is required, it should be determined. For 72 elements, Ar(E) values and their evaluated uncertainties (in parentheses, following the last significant digit to which they are attributed) are given. Names of elements with atomic number 113, 115, 117, and 118 are provisional; they have been reported in the peer-reviewed, scientific literature, but they have not yet been named by IUPAC

Table 2.2: Order of atomic number:

Order of atomic number					
Atomic number	Element name	Symbol	Atomic weight	See also Table/Figure	Footnotes
1	hydrogen	H	[1.00784, 1.00811]	6/3 in ref. [8]	m
2	helium	He	4.002602(2)		g r
3	lithium	Li	[6.938, 6.997]	6/4 in ref. [8]	m
4	beryllium	Be	9.0121823(3)		
5	boron	B	[10.806, 10.821]	6/5 in ref. [8]	m
6	carbon	C	[12.0096, 12.0116]	6/1	
7	nitrogen	N	[14.00643, 14.00728]	6/6 in ref. [8]	
8	oxygen	O	[15.99903, 15.99977]	6/7 in ref. [8]	
9	fluorine	F	18.9984032(5)		
10	neon	Ne	20.1797(6)		g m
11	sodium	Na	22.98976928(2)		
12	magnesium	Mg	[24.304, 24.307]	6/3	
13	aluminium (aluminum)	Al	26.9815386(8)		
14	silicon	Si	[28.084, 28.086]	6/8 in ref. [8]	
15	phosphorus	P	30.973762(2)		
16	sulfur	S	[32.059, 32.076]	6/9 in ref. [8]	
17	chlorine	Cl	[35.446, 35.457]	6/10 in ref. [8]	m
18	argon	Ar	39.948(1)		g r
19	potassium	K	39.0983(1)		
20	calcium	Ca	40.078(4)		
21	scandium	Sc	44.955912(6)		
22	titanium	Ti	47.867(1)		
23	vanadium	V	50.9415(1)		
24	chromium	Cr	51.9961(6)		
25	manganese	Mn	54.938045(5)		
26	iron	Fe	55.845(2)		
27	cobalt	Co	58.933195(5)		
28	nickel	Ni	58.6934(4)		r
29	copper	Cu	63.546(3)		r
30	zinc	Zn	65.38(2)		r
31	gallium	Ga	69.723(1)		
32	germanium	Ge	72.630(8)		
33	arsenic	As	74.92160(2)		
34	selenium	Se	78.96(3)		r
35	bromine	Br	[79.901, 79.907]	6/2	
36	krypton	Kr	83.798(2)		g m
37	rubidium	Rb	85.4678(3)		g
38	strontium	Sr	87.62(1)		g r

Chapter three:
X-ray

3.1 Introduction:

X-rays are widely used to reveal the structure of matter as well as to view inside of the body without making an incision. The use of X-rays has helped scientists and medical professionals alike for decades. However, the benefits come with risks. Unlike visible light, X-rays are not observable to the naked eye. Moreover, X-rays ionize the medium they pass through, which makes them dangerous to unprotected human body. Despite X-rays being extremely hazardous, their adverse effects can be minimized and the safety of appliances can be improved through proper measures and training [7].

3.2 Historical background:

The history of radiation protection starts from the nearly parallel discoveries of X-rays and radioactivity by the end of 19th century. In late 1895, Wilhelm Conrad Rontgen discovered X-rays when he was experimenting with the discharge of electricity in cathode ray vacuum tubes. During one experiment he had covered the vacuum tube with a black card board to block out its glow. However, he noticed emitting light on a fluorescent screen placed several feet away from the tube. He observed the "mysterious rays" passing through various solid objects. He also noticed the rays passing through his hand, where bones contrasted from muscles. This finding turned out to be a scientific bolt from the blue causing a great stir among scientists and public equally. For scientists and medical practitioners, the most interesting property of X-rays was their penetrability. Within months after the discovery, medical practitioners started to make radiographs to help them in their work. Though, the first radiograph showed an image of Roentgens wife's hand on a photographic plate.

In 1896, just two and a half months after the public announcement of Rontgen's discovery, Henri Becquerel discovered radioactivity while he was

working on uranium containing phosphorescent materials. The emitted rays from uranium were thought to be of same kind as X-rays. The images produced by these rays were very fuzzy compared to those produced by X-rays. The lack of availability of uranium was an additional problem.

However, after the discovery of radium by Pierre and Marie Curie two years later the phenomenon of radioactivity gained widespread attention [7].

3.3 Production and properties of X-rays:

X-rays are type of electromagnetic radiation. They are similar to visible light but have far shorter wavelength having range from 0.01-10 nanometers. The wavelength corresponds approximately to energy in the range 100 eV-100 keV. X-rays occupy the region between gamma and ultraviolet rays in the complete electromagnetic spectrum [8].

3.4 Production of X-rays:

X-rays can be produced by radioactive sources (e.g. Iron-55), particle accelerators in form of synchrotron radiation (where user has choice to select the wavelength required) or by an X-ray tube. In our laboratory X-rays are produced by X-ray tubes that use high voltage to accelerate the electrons released by a hot cathode. The electrons impact on a metal target at high speed resulting in X- rays production Kinetic energy of electrons striking at the target is mostly converted in to heat, only less than 1% is transformed into X-rays In general, the X-ray tube yields continuous and characteristic X-rays[8].

.3.5 Continuous X-rays:

Continuous X-rays are produced when electrons slowdown in the strong electric field near the nucleus of an atom. The decrease in the kinetic energy E of the electrons transforms to the energy of photon with frequency as

$$E = h\nu = \frac{hc}{\lambda} \qquad (3.1)$$

Where h is Planck's constant and c is the speed of light. When an electron loses all of its energy in a single collision, energy of the generated X-ray photon is obtained from the accelerating voltage (V) as

$E_{max}= e \ v$ (3.2)

Where e is charge of an electron. Since we know the value of Planck's constant (h), the speed of light (c), and the charge of an electron (e), equation (3.1) can be rewritten as

$\lambda = \dfrac{12.398}{v}$ (3.3)

Where V is in kilovolts and in angstroms. Upon increasing the voltage of X-ray tube we get shorter wavelength The total intensity (I), defined as the number of X-ray counts recorded at any energy within an energy dispersive spectrum of continuous X-rays is proportional to the tube current (i) as [9]

$I = A_i Z V^2$ (3.4)

Where A is the constant of proportionality and Z is the atomic number of target element [9] .
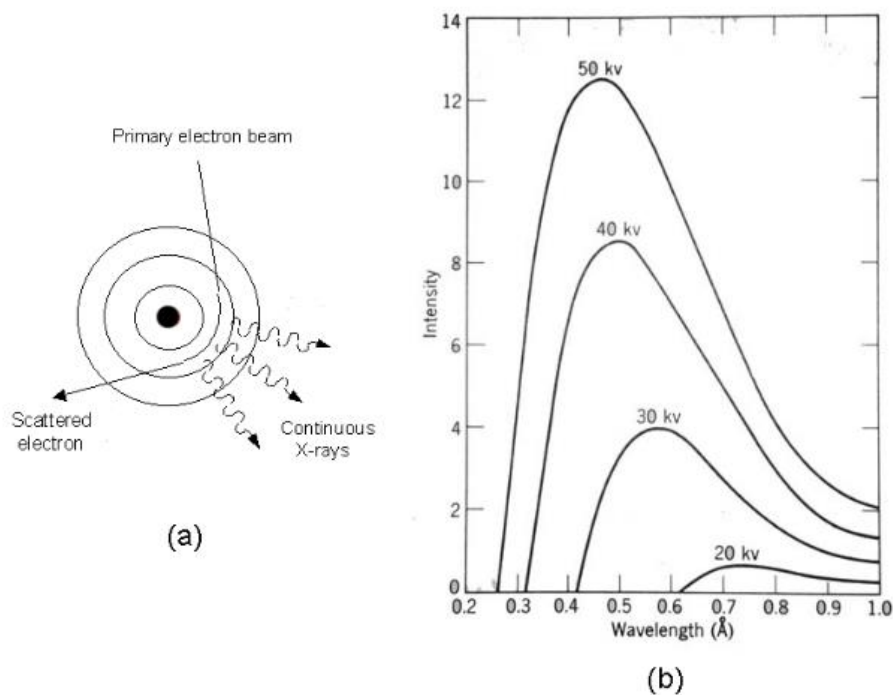

Figure (3.1): (a)Production of continuous X-rays(b) Continuous Spectrum.

When large amount of continuous radiation is needed, it is necessary to use a heavy target material, for example, tungsten (Z=74) and highest possible applied voltage. Continuous X-rays are also known as Bremsstrahlung or white radiation

3.6 Characteristic X-rays:

When a high speed electron strikes an atom, it dislocates a tightly bound electron from the atoms inner shell. An electron from an outer shell falls into the vacant place resulting in the emission of X-ray being characteristic of the atom in question. When we raise the voltage of an X-ray tube above a certain critical value, very sharp intensity maxima appear at specific wavelengths. Those characteristic lines are superimposed on the continuous spectrum and fall into several sets, referred to as K, L, M and so on as shown in figure [10] .
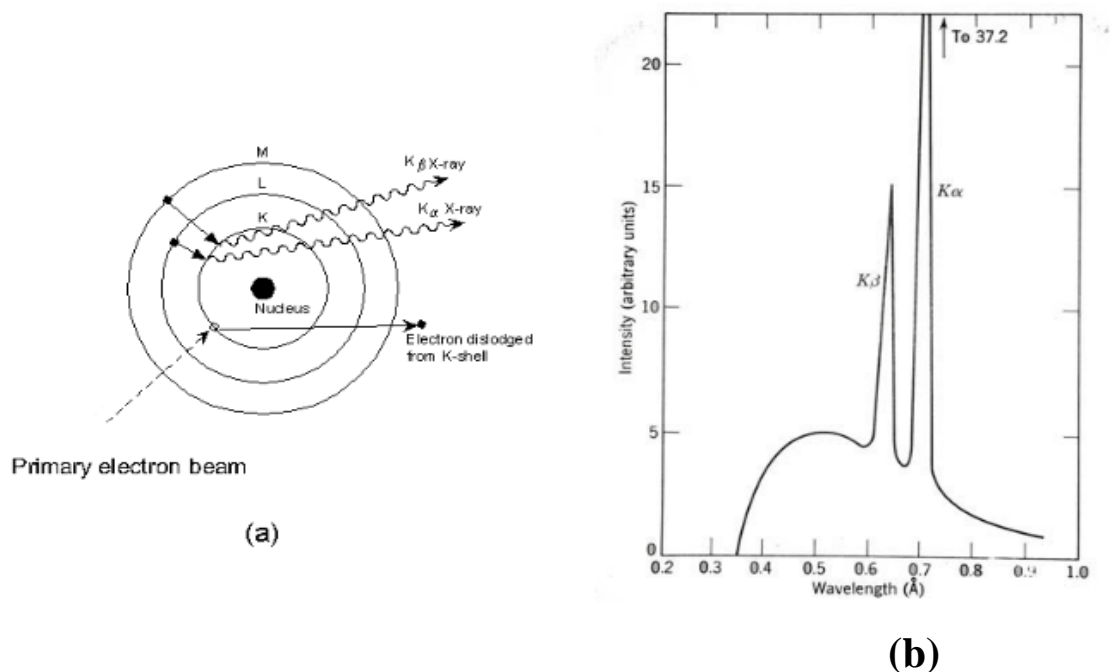
Figure 3.2: (a) Production of characteristic X-rays (b) spectrum lines

3.7 Interaction of X-rays with Matter:

Theoretically there are twelve processes that can occur when X-rays interact with matter. Usually, only three of these processes are important from the point of view of radiation protection. These processes are photoelectric effect, Compton Effect and pair production.

The photoelectric elect occurs when the incident photon is totally absorbed by an atom and an electron is ejected. This process leaves the atom in an excited state. The atom then returns to the ground state with the emission of an X-ray characteristic of the atom or with emitting an electron (Auger effect). Photoelectric absorption is the dominant process for X- ray absorption up to energies of about 500 keV and for atoms of high atomic numbers.

The Compton Effect also known as incoherent scattering, occurs when the incident X-ray photon ejects an electron from an atom and an X-ray photon of lower energy is scattered from the atom. Relativistic energy and momentum are conserved in this process. The scattered X-ray photon has less energy and therefore greater wavelength than the incident photon. Compton scattering is important for low atomic number sample [11].

3.8 Attenuation of X-rays:

Attenuation is the decrease of the flux of X-ray photons when passing through matter.

It depends on the energy of photons and the thickness density and atomic number of the material the photons are passing through For a narrow beam of mono energetic photons, the X-ray beam flux some distance x passing through a material can be expressed as[12].

$$\Psi = \Psi_0 e^{-\mu x} \tag{3.5}$$

Where μ is the linear attenuation coefficient. It is the probability of an interaction per unit distance travelled. It is directly proportional to the physical density and atomic number of material and inversely proportional to the photon energy. Linear attenuation coefficients expressed in inverse centimeters (cm)

$$\left(\frac{\mu}{\rho}\right) = \omega_1 \left(\frac{\mu}{\rho}\right)_1 + \omega_2 \left(\frac{\mu}{\rho}\right)_2 + \cdots = \sum_{j=1} \omega_j \left(\frac{\mu}{\rho}\right)_j \qquad (3.6)$$

Where ρ is the bulk density and wj represents the weight ratio for each element [10].

3.9 Biological Effects of X-rays:

X-rays are ionizing radiation and have potential to disrupt the structure of organic molecules in cells. Generally, biological effects of radiation begin with the ionization of atoms.

Ionizing radiation absorbed by human tissue has enough energy to remove electrons from the atoms that make up molecules of the tissue. The affected tissues further affect organs and hence, the whole human body [13].

3.10 Direct and Indirect Effect:

Chromosomes are considered to be the most critical target to X-rays since they contain the genetic information and instructions required for the cell to perform its function and to make copies of itself for reproduction purposes. A chromosome is an organized package of DNA found in the nucleus of the cell. Direct effect includes the direct ionization of the DNA molecule which may result in genetic damage. This kind of damage can disturb the reproduction and survival of the cells.

However, DNA counts for a very small portion of a cell. The human body mostly consists of water molecules upon exposure of ionizing radiation. There are more chances that radiation will interact with water molecules. This interaction might result in formation of free radicals [14].

3.11 Effects of Radiation On Cells:

The sensitivity of human body's organs is directly related to the sensitivity of cells. However, all cells are not exactly identical and hence they are not equally sensitive to radiation. For example, germ line cells are particularly sensitive to radiation while mature differentiated cells are less sensitive. Living cells can be classified upon their reproduction rate and the

relative sensitivity towards radiation Lymphocytes known also as white blood cells are most sensitive to radiation as they regenerate constantly. Reproductive and gastrointestinal cells are not regenerating as quickly as lymphocytes and therefore they are less sensitive. Nerve and muscle cells regenerate very slowly, and hence they are least sensitive cells to radiation [15].

3.12 Effects of Radiation On Organs and Body:

The human body is made up of many organs, and each organ of the body is made up of specialized cells. Hence, the sensitivity of the various organs of the human body is associated with the relative sensitivity of the cells. For example, the blood forming cells are one of the most sensitive cells due to their rapid regeneration rate; the blood forming organs are one of the most sensitive organs to radiation. Muscle and nerve cells were relatively insensitive to radiation, and therefore, so are the muscles and the brain.

The factors that affect the whole body from exposure of radiation depend on the total dose being received by a person, type of cells being exposed to radiation, type of radiation, age of an individual being exposed, part of body exposed as some parts are more sensitive than others, general state of health of an individual, and time interval over which dose is received [16].

3.13 Deterministic Radiation Effects:

Deterministic effects, also known as non-stochastic effects, are those responses which increase in severity with increased radiation dose. Deterministic effects occur when human body receives high radiation dose over relatively short amount of time. This affects results in lots of dead cells. Deterministic effect is characterized by a threshold below which the effect is not seen. This threshold varies from person to person as well as from tissue to tissue. Short-term, high-level exposure is referred to as acute exposure. Acute radiation syndromes are classified as; the hemopoietic syndrome, the gastrointestinal (GI) syndrome and the central nervous system (CNS) syndrome [16].

3.14 Radiation Safety in Practice:

This part of the thesis deals with the analytical X-ray equipment at the Department of Physics, University of Helsinki. A powder diffractometer and a Laue system were chosen for a closer study. Both of these equipment are used for materials characterization and make use of a very narrow and high-intensity X-ray beam [16].

3.15 Diffraction Of X-rays:

Diffraction is an encroachment of radiation towards the geometric shadow region when it passes at the sharp edged obstacle. It deviates from its rectilinear path. Diffraction also occurs when a wave is incident on a series of regularly spaced obstacles, such that:

(i) They are capable of scattering the wave,

(ii) They have spacing, which are comparable with the wavelength of the radiation. Diffraction pattern is a modification of intensity when several scattered waves are superposed constructively or destructively. X-rays are electromagnetic and powerful radiation and have wavelength range of 10·10m to 10·14 m, the order of which is comparable to that of atomic spacing in crystals. In 1912, the German physicist Max VonLaue predicted that x-rays can be diffracted from crystal samples. X-rays incident on crystal lattice are partly scattered by electrons and partly by the ions of the lattice sites. The directions and intensities would be dependent upon the lattice structure and chemical composition of the crystal. These predictions were soon verified by the experimental work of Friedrich and Knipping.

In light experiments, the plane diffraction grating has superior resolution, so that it gives rise to spectral lines which are clearly separated from one another. This helps to measure the wavelengths of spectral lines accurately. If 'd' be the slits spacing and n are the order of diffraction, the condition for diffraction maxima is [17].

$$d \sin \theta = n\lambda \qquad (3.7)$$

For reasonable values of Sin θ, d must be of the order of the wavelength.

For diffraction gratings, d

» 1.6 x 10-6 m, which can be produced mechanically by diamond rulings on an optically plan1iglass plate. But gratings for x-rays cannot be produced mechanically. A grating of slit width less than lOA is needed for x-ray diffraction. This width is compare able to the interatomic spacing in crystals. In order to study x-ray spectra and crystal structure, a powerful tool such as x-ray diffraction process is needed. The crystal spacing shall act as a three dimensional grating for x-ray diffraction.

Using the crystals as gratings, epoch making experiments in the history of x-ray spectra and crystal structure analysis were conducted by Laue at Germany, and by Williams Lawrence Bragg and his Father William Henry Bragg in England, during 1913. They developed the methods of x-ray diffraction relating wavelength of x-rays and interatomic spacing 'a' or interplanar distance of (hkl) family in the crystal. They are related to one another as

$$d_{hk1} = \frac{a}{\sqrt{h^2 + k^2 + i^2}} \tag{3.8}$$

In a unit cubic crystal structure. They were awarded Nobel Prize in Physics, in 1915 for their study of crystal structure by x-ray diffraction method.

In a crystal structure there are families of principal planes belonging to particular Miller indices (hkl). These are the planes passing through the lattice sites. The incident x-rays are reflected specularly from successive planes of (hkl) family. They are superposed and detected or photographed to measure their intensities

. The location of diffraction maxima were explained by W.L. Bragg and is called Bragg's law, the description of which is as described below [17].

Chapter four

The Experimental Work

4.1 Introduction:

The word attenuation of x-ray means decreases in intensity that occurs when the radiation passes through matter. The attenuation is caused mainly by tow effect: scattering and absorption.

4.2 Device and Equipment:

1- Computer
2- Geiger miler counter
3- X- ray machine

4.3 Theory:

$$R = R_o e^{-\mu d} \qquad (4.1)$$

$$\frac{R}{R_o} = e^{-\mu d} \qquad (4.2)$$

$$\text{Ln } T = -\mu d \qquad (4.3)$$

Where R0 is the original counting rate in front of the attenuation

R is the counting rate behind it

μ is attenuation coefficient

T is transmittance

d is attenuation

4.4 Methodology:

-in this research the work has been carried out through experiment using x-ray Apparatus with different thickness for aluminum foils and using with different material but with the same thickness .

-The results obtained was analyzed.

4.5 Result:

Table (4.1): counting rate(R/s) as a function of thickness (d/mm) of the aluminum absorbers:

B	d/mm	R/S	T=R/R$_O$	Ln T
0	0	773.7	1.00	0.00
10	0.5	304.16	0.393	-0.934
20	1	135.97	0.176	-1.74
30	1.5	67.42	0.087	-2.44
40	2	31.10	0.040	-3.22
50	2.5	20.53	0.026	-3.64
60	3	9.36	0.013	-4.34

Table (4.2): counting rate(R/s) as a function of Atomic number (z):

Absorber	Z	B	d/mm	R/S	T=R/R$_O$	Ln T	μ= Ln T/d
None		0	0.5	2864.20	1.00	0.00	0.00
C	6	10	0.5	2763.07	0.964	-0.036	-0.072
Al	13	20	0.5	1681.73	0.587	-0.533	-1.066
Fe	26	30	0.5	337.62	0.118	-2.14	-4.28
Cu	29	40	0.5	52.20	0.018	-4.017	-8.034
Zr	40	50	0.5	132.84	0.046	-3.79	-6.158
Ag	47	60	0.5	27.73	9.68	2.27	4.54
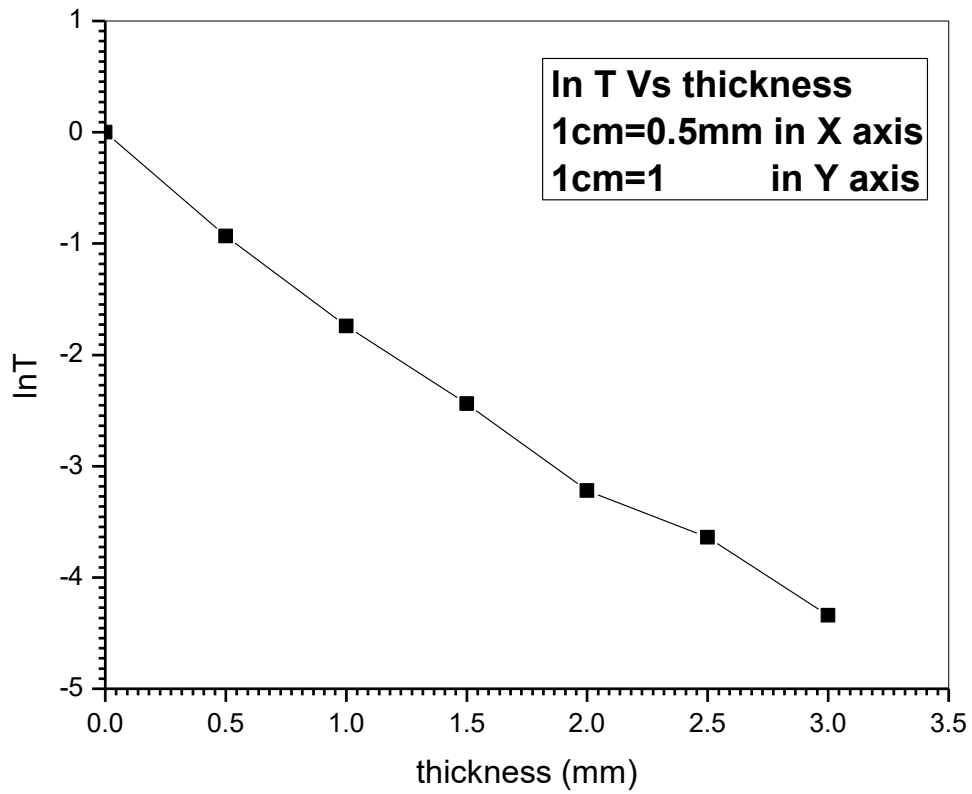
Figure (4.1): relation between ln (t) and thickness of Aluminum absorber (d)
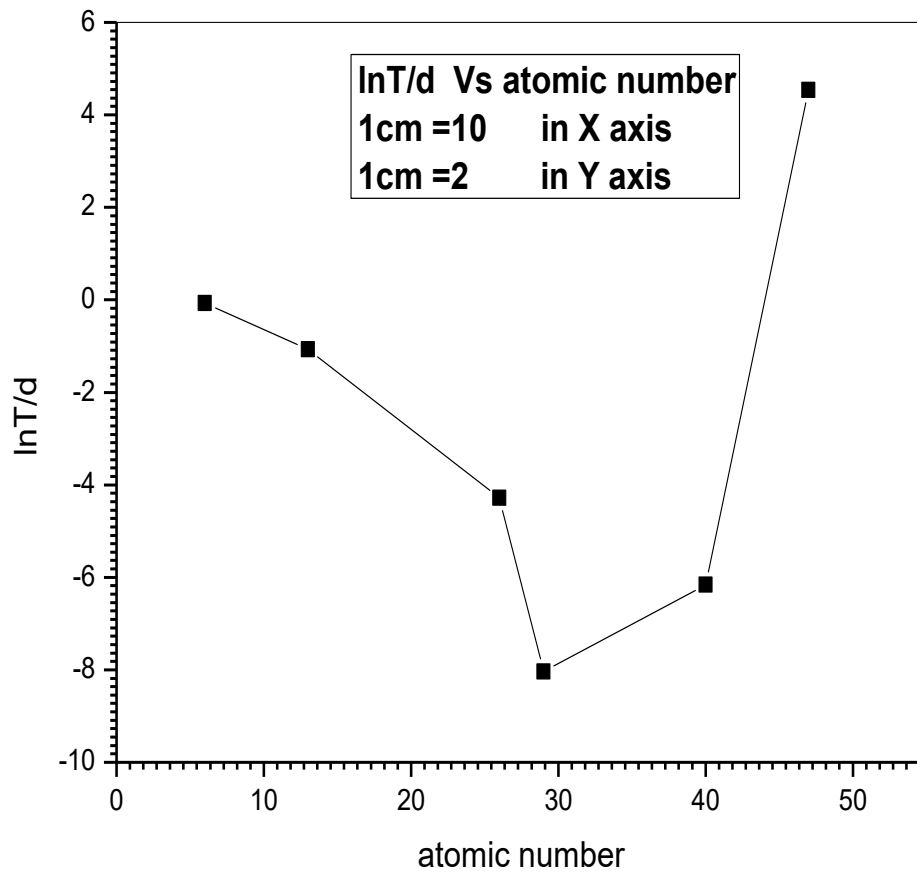
Figure (4.2): shows relation between atomic number (z) and attenuation coefficient for different elements (μ)

4.6 Discussion:

Figure (4.1) shows the relation of logarithms attenuation coefficient of x -ray and the thickness of aluminum which it showed inversely proportionality relationship.

From figure (4.2) It is clear that that the attenuation coefficient depend on the atomic number (function in atomic number) so it decreases by increasing atomic numbers exponentially but it noticed that some elements with greater atomic number but have less attenuation coefficient due to its crystal structure.

4.7 Conclusion:

Investigating the attenuation of x-rays as a function of the absorber material and absorber thickness

-this attenuation is caused mainly by two effects:

Scattering and absorption although absorption and attenuation are different physical phenomena.an absorber this should more properly be termed an attenuation .

The scattering of x-ray quanta at the atoms of the attenuation materials

Cause a part of the radiation to change direction this reduces the intensity in the original direction.

4.8Recommendations:

- In the future work the experiment must be carried out using a mixture or alloy for different elements.

- New substance must be conducted in order to detect which substance will be good shield.

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