CRYSTALLOGRAPHIC ARRANGEMENT OF FCC ATOMS INTO PLANES

BY

KWAV LUBEM MICHAEL

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DEPARTMENT OF PHYSICS FACULTY OF PHYSICAL SCIENCES

UNIVERSITY OF BENIN

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SUBMITTED TO DEPARTMENT OF PHYSICS, FACULTY OF PHYSICAL SCIENCES UNIVERSITY OF BENIN, BENIN CITY, NIGERIA. IN PARTIAL FULFILLMENT FOR THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (BSc) IN INDUSTRIAL PHYSICS

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CERTIFICATION

This is to certify that this project work was carried out by Kwav Lubem Michael, in the department of Physics, Faculty of Physical Sciences, University of Benin, Benin City under the supervision of Prof.E Aghemenloh.

…… ……

PROF. E. AGHEMENLOH DATE

PROJECT SUPERVISOR

……. ……..

PROF. C. O. AIGBOGUN DATE

HEAD OF DEPARTMENT

…… ……..

EXTERNAL EXAMINER DATE

DEDICATION

This project is dedicated to God Almighty who provided me with strength I needed to make this work possible; my life, health, and the help of others. I also dedicate this work to my mom Mrs. Lucy Bimbo, who is a source of inspiration support and much love to my brother Terhemba kwav for his support .

ACKNOWLEDGEMENT

I sincerely appreciate the invaluable guidance and support of my project supervisor, **Prof E. AGHEMALO**. Their dedication, expertise, and insightful feedback have been instrumental in shaping the direction of this research. Your unwavering commitment to excellence and encouragement throughout this study have greatly contributed to the successful completion of this work. I am truly grateful for your diligent efforts in mentoring and assisting me throughout this project

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ABSTRACT

The face-centered cubic (FCC) crystal structure is one of the most significant arrangements in materials science, particularly in metals such as aluminum, copper, and gold. This research explores the crystallographic arrangement of FCC atoms into distinct planes, emphasizing their geometric configuration, atomic packing, and the significance

of close-packed structures. The study provides an in-depth analysis of Miller indices to describe the most prominent planes in FCC lattices, including the {111}, {110}, and {100} planes.

CHAPTER ONE

1.1 Background of the Study

Crystallography is the study of the arrangement of atoms within crystalline solids. It is a fundamental aspect of materials science and has numerous applications in fields such as physics, chemistry, and engineering. One of the most common crystal structures is the Face-Centered Cubic (FCC)structure, which is found in many metals and alloys.

The FCC crystal structure consists of a cube with atoms located at the corners and at the face of the cube. The atoms at the corners touch the atom in the center along the body diagonal of the cube (Kittel, 2005). The FCC structure is found in many metals and alloys, such as Aluminum (Al), Copper (Cu), Iridium (Ir), Lead (Pb), **Nickel (Ni)**: (Smith, 1993).

The arrangement of atoms in a crystal is known as the crystal structure, and it plays a crucial role in determining the physical and chemical properties of the material (Cullity and Stock, 2001).

1.2 History of Crystallography

The study of crystallography dates back to the 17th century, when scientists such as Robert Hooke and Christiaan Huygens first observed the regular arrangement of atoms in crystals (Hooke, 1665; Huygens, 1690). However, it wasn't until the 20th

century that the development of X-ray diffraction techniques allowed scientists to determine the crystal structure of materials with high precision (Bragg, 1913).

The crystallographic arrangement of atoms in a material plays a crucial role in determining its physical and chemical properties. The arrangement of atoms in a crystal determines the material's strength, conductivity, optical properties, and reactivity (Callister, 2007). Understanding the crystallographic arrangement of atoms in a material is essential for designing and optimizing materials for specific applications...

1.3 Crystals, lattice and unit cell

A crystal is a solid material where the constituent atoms, molecules, or ions are arranged in a highly ordered, repeating pattern that extends throughout the entire structure. This long-range order distinguishes crystals from amorphous solids (like glass) where the arrangement is disordered.

A crystal lattice is a 3D array of points in space representing the positions of atoms, ions, or molecules in a crystal, characterized by a repeating, symmetrical pattern that extends throughout the entire structure.

A lattice maybe one, two or three dimensional. The atomic order in crystalline solids indicates that a small group of atoms form a repetitive pattern known as unit

cells unit. Cells for most crystal structures are parallelepiped or prisms having three sets of parallel faces. The unit cell is the smallest repeating block of atoms, ions, or molecules that makes up the entire crystal structure

1.4 Crystallographic directions

Crystallographic directions are a way to specify orientations within a crystal lattice, which is the repeating pattern of atoms in a crystal. They are essential for understanding how materials behave because many properties, like strength or conductivity, can vary depending on the direction within the crystal. The established labeling convention involve uses of three integers or indices to designate directions and planes. The basis for determining the index values is the unit cell with a coordinate system of three (x, y , z) axes situated along one and coinciding with the unit cell .

For each of the three axes, there will be both positive and negative coordinates. The negative indices are represented by a bar over the appropriate index.

1.5 Crystallographic planes

Crystallographic planes are a fundamental concept in materials science, crucial for understanding various phenomena like crystal growth, deformation, and diffraction. Crystallographic planes are imaginary planes that cut through a crystal lattice, intersecting lattice points. They represent sets of parallel and equidistant planes that extend throughout the crystal structure. These planes are crucial because they relate directly to material properties and behavior. The Crystallographic planes of all crystals except hexagonal crystal are specified by three miller indices as (h k l). Any two planes parallel to each other are equivalent and have identical indices. An intercept on the negative side of the origin is indicated by a bar or minus sign positioned over the appropriate index. Reversing the directions of all indices specifies another plane parallel to, on opposite side and equidistant from the origin.

The arrangement of FCC atoms into planes is influenced by the crystallographic parameters, such as lattice parameters, atomic positions, and bond lengths (Ashcroft and Mermin 1976).

1.6 Research Aim and objectives

The aim of this research is to investigate the crystallographic arrangements of atoms of FCC into planes.

Specifically, the research aims to:

1. _Determine the crystallographic parameters of FCC atoms_: This involves calculating the lattice parameter, such as atomic positions, with reference to the atom at center as the origin

2. _Investigate the arrangement of FCC atoms into planes_: This involves studying the crystallographic planes that can be formed by FCC atoms and determining their orientation and spacing.

3. obtain the number of next nearest neighbor (NNN)

The main objective of this research is to investigate the crystallographic arrangement of FCC atoms into planes.

This research is significant because it will provide a comprehensive understanding of the crystallographic arrangement of FCC atoms into planes. This knowledge will be useful in understanding the properties of materials that exhibit the FCC structure, such as their strength, conductivity, and optical properties.

Furthermore, this research will contribute to the development of new materials with tailored properties, which is a major goal of materials science research. The study will also provide a framework for understanding the behavior of BCC atoms in different planes, which will be useful in the development of new technologies, such as nanotechnology and materials engineering.

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CHAPTER TWO

THEORY AND METHODS

2.1 crystallographic planes

Crystallographic planes are sets of parallel, equidistant planes that intersect the points of a crystal lattice (William Hallowes Miller's work in 1839) In FCC metals, the crystallographic planes are determined by the Miller indices (h k l), which describe the orientation of the plane with respect to the crystal lattice.

The arrangement of atoms in FCC crystals can be described using the concept of crystallographic planes.

The arrangement of atoms in an FCC (face-centered cubic) crystal structure can be precisely described using the lattice parameter, often denoted as

a =b=c lattice constant (edge length of the cube) it is the same across all the crystal structure

Interaxial Angles: The angles between the crystallographic axes are denoted as alpha (α), beta (β), and gamma (γ). In a cubic system, all these angles are equal to 90 degrees.

Therefore, for an FCC crystal:

- $\alpha = 90$ degrees
- $\beta = 90$ degrees
- $\gamma = 90$ degrees

This 90-degree angle is a direct consequence of the cubic symmetry of the FCC structure.

The FCC structure can be represented by the following crystallographic planes:

(100): planes perpendicular to the x-axis

(110}: planes perpendicular to the x-y plane

(111): planes perpendicular to the x-y-z plane

The Miller indices are defined as:

- h: reciprocal of the intercept of the plane with the x-axis

- k: reciprocal of the intercept of the plane with the y-axis

- l: reciprocal of the intercept of the plane with the z-axis

For example, the Miller indices for the {100} plane are (100), which means that the plane intersects the x-axis at 1 unit and is parallel to the y-z plane.

The crystallographic arrangements of FCC atoms into planes can be described by the Miller indices and the interplanar spacing. Bragg's Law describes the

diffraction of X-rays by a crystal lattice, which can be used to determine the crystal structure of a material.

The arrangements of atoms in a crystal lattice can be described with respect to a 3 dimensional net of straight lines as shown below (2.1a).The line divide space into equal sized parallelopiped and the intersection of the lines is called a space lattice. Every point of a space lattice has identical surroundings. In single structures, the space lattice is usually constructed so that the lattice points correspond to atomic positions in the crystal but it is not essential that every atomic site corresponds with a lattice site. Each parallelopiped is called a unit cell and the crystal is constructed by stacking identical unit cells face to face in perfect alignment in 3 dimensions.

The positions of the planes, directions and point sites in a lattice are described by reference to a unit call and the three principal axis x,y and z as shown in fig(2.1b) below.

Stacking patterns refer to the arrangement of atoms or molecules in a crystalline solid, specifically in a layered or planar structure. In the context of BCC (Body-Centered Cubic) metals, stacking patterns describe the sequence of atomic layers in the crystal lattice.

Types of Stacking Patterns

There are several types of stacking patterns, including:

1. *ABCABC...* (Face-Centered Cubic, FCC): This stacking pattern is characteristic of FCC metals, where each layer is offset from the previous one by one-third of the lattice parameter.

2. *ABAB...* (Hexagonal Close-Packed, HCP): This stacking pattern is characteristic of HCP metals, where each layer is offset from the previous one by one-half of the lattice parameter.

3. *AAA...* (Body-Centered Cubic, BCC): This stacking pattern is characteristic of BCC metals, where each layer is identical to the previous one, with no offset.

To obtain the stacking pattern for BCC atoms, we need to consider the crystal structure of BCC metals. In a BCC lattice, each atom is located at the center of a cube, with eight nearest neighbors located at the corners of the cube.

The stacking pattern for F1`CC atoms can be obtained by projecting the crystal lattice onto a plane. Let's consider the (100) plane, which is perpendicular to the x-axis.

1. *Layer 1*: The first layer consists of atoms located at the corners of the cube, with coordinates (0, 0, 0), (0, 0, 1), (0, 0, -1), and (-1, 0, -1).

2. *Layer 2*: The second layer consists of atoms located at the center of the cube with coordinates (1/2, 1/2, 1/2).

3. *Layer 3*: The third layer is identical to the first layer, with atoms located at the corners of the cube.

By repeating this sequence of layers, we obtain the stacking pattern for BCC atoms: *AAA...* which reflects the identical arrangement of atomic layers in the crystal lattice. This stacking pattern is a characteristic feature of BCC metals and plays an important role in determining their physical and chemical properties.

For calculating the distance for each atomic positionings=$\sqrt{x^2+y^2+z^2}$

2.2 Theoretical Models

Several theoretical models have been developed to describe the crystallographic arrangements of BCC atoms into planes. These models include:

1. *Bragg-Williams Model*: This model describes the arrangement of atoms in a crystal lattice in terms of the probabilities of finding an atom at a particular lattice site (Bragg and Williams, 1934).

The Bragg-Williams model was first introduced by William Henry Bragg and Egon Williams in 1934. The model is based on a mean-field approximation, which assumes that the behavior of an individual atom is representative of the behavior of all atoms in the system.

The Bragg-Williams model can be applied to the FCC (face-Centered Cubic) lattice to study the crystallographic arrangements of atoms into planes.

The Bragg-Williams model can be used to study the crystallographic arrangements of FCC atoms into planes by considering the occupation numbers of the lattice. The occupation numbers can be mapped onto the crystallographic arrangements of atoms into planes.

2. *Ising Model*: This model describes the arrangement of atoms in a crystal lattice in terms of the interactions between neighbouring atoms (Ising, 1925).

The Ising model was first introduced by Wilhelm Lenz in 1920 and later developed by Ernst Ising in 1925.

The Ising model can be applied to the BCC (Body-Centered Cubic) lattice to study the crystallographic arrangements of atoms into planes.

The Ising model can be used to study the crystallographic arrangements of BCC atoms into planes by considering the spin configurations of the lattice. The spin configurations can be mapped onto the crystallographic arrangements of atoms into

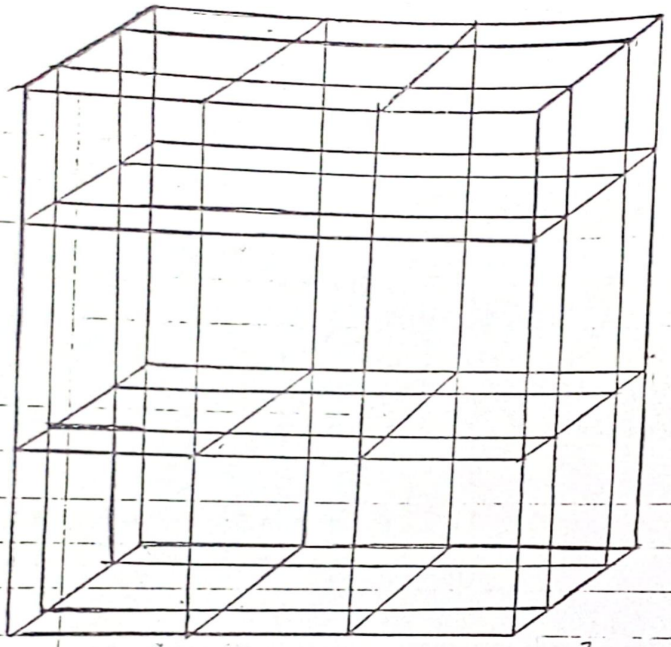


Fig (2.1a)

Ref 8a

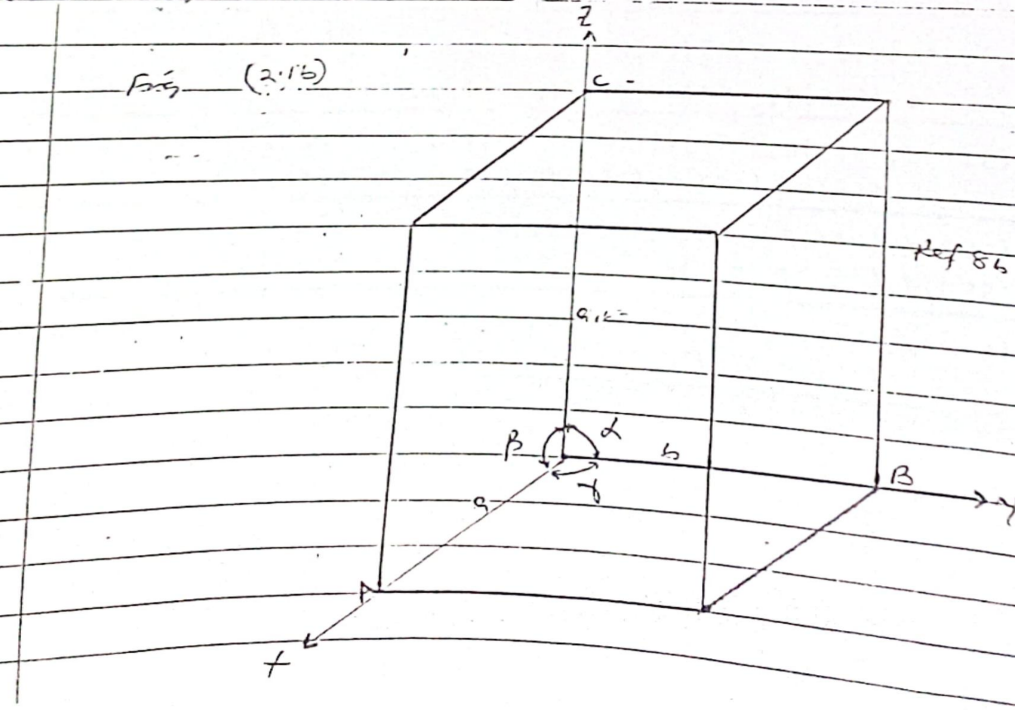


Fig (2.1b)

~~Ref 8a~~

CHAPTER THREE

ATOMIC COORDINATES AND THEIR DISTANCES

b= $\frac{a}{2}$,

a_1=a,

a_2= $\frac{a}{2}$= a_5=a_6

a_3=a=a_4

Atomic number	Atomic coordinates	Atomic distances
0	(000)	0
1	(001)a_1	a
2	(00$\bar{1}$)a_1	a
3	($\bar{1}$0$\bar{1}$)a_2	$\frac{a\sqrt{2}}{2}$
4	(101)a_2	$\frac{a\sqrt{2}}{2}$
5	($\bar{1}$01)a_1	a
6	(100)a_1	a

7	$(\bar{1}01)a_2$	$\frac{a\sqrt{2}}{2}$
8	$(10\bar{1})a_2$	$\frac{a\sqrt{2}}{2}$
9	$(011)a_2$	$\frac{a\sqrt{2}}{2}$
10	$(0\bar{1}\bar{1})a_2$	$\frac{a\sqrt{2}}{2}$
11	$(010)a_1$	a
12	$(01\bar{1})a_1$	a
13	$(01\bar{1})a_2$	$\frac{a\sqrt{2}}{2}$
14	$(0\bar{1}1)a_2$	$\frac{a\sqrt{2}}{2}$
15	$(\bar{1}0\bar{1})a_3$	$a\sqrt{3}$
16	$(1\bar{1}1)a_3$	$a\sqrt{3}$
17	$(\bar{1}10)a_3$	$\frac{a}{2}\sqrt{2}$
18	$(1\bar{1}0)a_2$	$\frac{a}{2}\sqrt{2}$
19	$(\bar{1}11)a_3$	$a\sqrt{3}$
20	$(1\bar{1}\bar{1})a_2$	$a\sqrt{3}$
21	$(111)a_3$	$a\sqrt{3}$

22	$(\bar{1}\bar{1}2)a_2$	$\frac{a}{2}\sqrt{6}$
23	$(110)a_2$	$\frac{a}{2}\sqrt{2}$
24	$(\bar{1}\bar{1}0)a_2$	$\frac{a}{2}\sqrt{2}$
25	$(11\bar{1})a_3$	$a\sqrt{3}$
26	$(\bar{1}\bar{1}1)a_3$	$a\sqrt{3}$
27	$(\bar{1}01)a_4$	$\sqrt[a]{2}$
28	$(10\bar{1})a_4$	$\sqrt[a]{2}$
29	$(\bar{1}0\bar{1})a_4$	$\sqrt[a]{2}$
30	$(101)a_4$	$\sqrt[a]{2}$
31	$(01\bar{1})a_4$	$\sqrt[a]{2}$
32	$(01\bar{1})a_4$	$\sqrt[a]{2}$
33	$(011)a_4$	$\sqrt[a]{2}$
34	$(1\bar{1}2)a^5$	$\frac{a}{2}\sqrt{6}$
35	$(\bar{1}10)a_4$	$\sqrt[a]{2}$
36	$(1\bar{1}0)a_4$	$\sqrt[a]{2}$
37	$(110)a_4$	$\sqrt[a]{2}$
38	$(\bar{1}\bar{1}0)a_4$	$\sqrt[a]{2}$

39	$(\bar{1}12)a_5$	$\frac{a}{2}\sqrt{6}$
40	$(1\bar{1}\bar{2})a_5$	$\frac{a}{2}\sqrt{6}$
41	$(\bar{1}1\bar{2})a_5$	$\frac{a}{2}\sqrt{6}$
42	$(\bar{1}1\bar{2})a_4$	$\sqrt[a]{2}$
43	$(112)a_5$	$\frac{a}{2}\sqrt{6}$
44	$(\bar{1}\bar{1}\bar{2})a_5$	$\frac{a}{2}\sqrt{6}$
45	$(11\bar{2})a_5$	$\frac{a}{2}\sqrt{6}$
46	$(\bar{1}\bar{1}\bar{1})a_3$	$a\sqrt{3}$
47	$(121)a_5$	$\frac{a}{2}\sqrt{6}$
48	$(\bar{1}\bar{2}\bar{1})a_5$	$\frac{a}{2}\sqrt{6}$
49	$(12\bar{1})a_5$	$\frac{a}{2}\sqrt{6}$
50	$(\bar{1}\bar{2}1)a_5$	$\frac{a}{2}\sqrt{6}$
51	$(\bar{1}2\bar{1})a_5$	$\frac{a}{2}\sqrt{6}$
52	$(1\bar{2}1)a_5$	$\frac{a}{2}\sqrt{6}$

53	$(\bar{1}21)a_5$	$\frac{a}{2}\sqrt{6}$
54	$(1\bar{2}1)a_5$	$\frac{a}{2}\sqrt{6}$
55	$(\bar{2}\bar{1}1)a_5$	$\frac{a}{2}\sqrt{6}$
56	$(21\bar{1})a_5$	$\frac{a}{2}\sqrt{6}$
57	$(\bar{2}\bar{1}\bar{1})a_5$	$\frac{a}{2}\sqrt{6}$
58	$(211)a_5$	$\frac{a}{2}\sqrt{6}$
59	$(\bar{2}11)a_5$	$\frac{a}{2}\sqrt{6}$
60	$(2\bar{1}\bar{1})a_5$	$\frac{a}{2}\sqrt{6}$
61	$(\bar{2}1\bar{1})a_5$	$\frac{a}{2}\sqrt{6}$
62	$(2\bar{1}1)a_5$	$\frac{a}{2}\sqrt{6}$
63	$(\bar{2}00)a_1$	2a
64	$(200)a_1$	2a
65	$(\bar{3}1\bar{2})a_6$	$\frac{a}{2}\sqrt{14}$
66	$(3\bar{1}2)a_6$	$\frac{a}{2}\sqrt{14}$

67	$(031)a_6$	$\frac{a}{2}\sqrt{10}$
68	$(0\bar{3}\bar{1})a_6$	$\frac{a}{2}\sqrt{10}$
69	$(31\bar{2})a_6$	$\frac{a}{2}\sqrt{14}$
70	$(\bar{3}\bar{3}2)a_6$	$\frac{a}{2}\sqrt{22}$
71	$(03\bar{1})a_6$	$\frac{a}{2}\sqrt{10}$
72	$(0\bar{3}1)a_6$	$\frac{a}{2}\sqrt{10}$
73	$(\bar{3}21)a_6$	$\frac{a}{2}\sqrt{14}$
74	$(3\bar{2}1)a_6$	$\frac{a}{2}\sqrt{14}$
75	$(321)a_6$	$\frac{a}{2}\sqrt{14}$
76	$(\bar{3}\bar{2}1)a_6$	$\frac{a}{2}\sqrt{14}$
77	$(020)a_1$	2a
78	$(0\bar{2}0)a_1$	2a
79	$(\bar{3}2\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$
80	$(3\bar{2}\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$
81	$(02\bar{1})a_1$	$\sqrt[a]{5}$

82	$(0\bar{2}1)a_1$	$\sqrt[a]{5}$
83	$(32\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$
84	$(\bar{3}\bar{2}\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$
85	$(\bar{3}12)a_6$	$\frac{a}{2}\sqrt{14}$
86	$(3\bar{3}2)a_6$	$\frac{a}{2}\sqrt{22}$
87	$(021)a_1$	$\sqrt[a]{5}$
88	$(0\bar{2}\bar{1})a_1$	$\sqrt[a]{5}$
89	$(312)a_6$	$\frac{a}{2}\sqrt{14}$
90	$(\bar{3}12)a_6$	$\frac{a}{2}\sqrt{14}$
91	$(\bar{2}21)a_1$	$\sqrt[2a]{5}$
92	$(2\bar{2}0)a_1$	$\sqrt[2a]{5}$
93	$(\bar{1}21)a_1$	$\sqrt[a]{6}$
94	$(1\bar{2}\bar{1})a_1$	$\sqrt[a]{6}$
95	$(\bar{2}01)a_1$	$\sqrt[a]{5}$
96	$(201)a_1$	$\sqrt[a]{5}$
97	$(330)a_6$	$\frac{3a}{2}\sqrt{2}$

98	$(\bar{3}\bar{3}0)a_6$	$\frac{3a}{2}\sqrt{2}$
99	$(221)a_1$	3a
100	$(\bar{2}\bar{2}\overline{\bar{1}})a_1$	3a
101	$(\bar{3}0\bar{1})a_6$	$\frac{a}{2}\sqrt{10}$
102	$(301)a_6$	$\frac{a}{2}\sqrt{10}$
103	$(\bar{2}3\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$
104	$(\bar{2}\bar{3}1)a_6$	$\frac{a}{2}\sqrt{14}$
105	$(\bar{3}01)a_6$	$\frac{a}{2}\sqrt{10}$
106	$(30\bar{1})$	$\frac{a}{2}\sqrt{10}$
107	$(\bar{3}10)a_6$	$\frac{a}{2}\sqrt{10}$
108	$(310)a_6$	$\frac{a}{2}\sqrt{10}$
109	$(12\bar{1})a_1$	$\sqrt[a]{6}$
110	$(1\bar{2}1)a_1$	$\sqrt[a]{6}$
111	$(\bar{2}\bar{1}\bar{1})a_1$	$\sqrt[a]{6}$
112	$(2\bar{1}1)a_1$	$\sqrt[a]{6}$

113	$(23\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$
114	$(43\bar{1})a_6$	$\frac{a}{2}\sqrt{26}$
115	$(\bar{1}2\bar{1})a_1$	$\sqrt[a]{6}$
116	$(\bar{1}\bar{2}1)a_1$	$\sqrt[a]{6}$
117	$(\bar{1}30)a_7$	$\frac{a}{2}\sqrt{10}$
118	$(\bar{1}\bar{3}0)a_6$	$\frac{a}{2}\sqrt{10}$
119	$(14\bar{1})a_6$	$\frac{3a}{2}\sqrt{2}$
120	$(1\bar{4}1)a_6$	$\frac{3a}{2}\sqrt{2}$
121	$(22\bar{1})a_1$	3a
122	$(\bar{2}\bar{2}1)a_1$	3a
123	$(\bar{2}31)a_6$	$\frac{a}{2}\sqrt{14}$
124	$(2\bar{3}\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$
125	$(120)a_1$	$\sqrt[a]{5}$
126	$(1\bar{2}0)a_1$	$\sqrt[a]{5}$
127	$(23\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$

128	$(2\bar{3}1)a_6$	$\frac{a}{2}\sqrt{14}$
129	$(\bar{3}\bar{1}0)a_6$	$\frac{a}{2}\sqrt{10}$
130	$(3\bar{1}0)a_6$	$\frac{a}{2}\sqrt{10}$
131	$(431)a_6$	$\frac{a}{2}\sqrt{26}$
132	$(41\bar{1})a_6$	$\frac{3a}{2}\sqrt{2}$
133	$(\bar{4}\bar{3}1)a_6$	$\frac{a}{2}\sqrt{26}$
134	$(\bar{2}\bar{3}\bar{1})a_6$	$\frac{a}{2}\sqrt{14}$
135	$(\bar{4}\bar{1}\bar{1})a_6$	$\frac{3a}{2}\sqrt{2}$
136	$(4\bar{1}1)a_6$	$\frac{3a}{2}\sqrt{2}$
137	$(\bar{4}\bar{3}\bar{1})a_6$	$\frac{a}{2}\sqrt{26}$
138	$(\bar{4}\bar{1}1)a_6$	$\frac{3a}{2}\sqrt{2}$
139	$(\bar{3}\bar{4}\bar{\bar{1}})a_6$	$\frac{a}{2}\sqrt{26}$
140	$(\bar{3}41)a_6$	$\frac{a}{2}\sqrt{26}$
141	$(411)a_6$	$\frac{3a}{2}\sqrt{2}$

142	$(\bar{4}\bar{1}1)a_6$	$\frac{3a}{2}\sqrt{2}$
143	$(\bar{1}\bar{4}1)a_6$	$\frac{3a}{2}\sqrt{2}$
144	$(\bar{1}4\bar{1})a_6$	$\frac{3a}{2}\sqrt{2}$
145	$(\bar{1}32)a_6$	$\frac{a}{2}\sqrt{14}$
146	$(\bar{1}\bar{3}\bar{2})a_6$	$\frac{a}{2}\sqrt{14}$
147	$(2\bar{2}\bar{1})a_1$	3a
148	$(\bar{4}41)a_6$	3a
149	$(210)a_1$	$\sqrt[a]{5}$
150	$(\bar{2}10)a_1$	$\sqrt[a]{5}$
151	$(220)a_1$	$\sqrt[2a]{2}$
152	$(211)a_1$	$\sqrt[a]{6}$
153	$(\bar{2}\bar{1}0)a_1$	$\sqrt[a]{5}$
154	$(2\bar{1}0)a_1$	$\sqrt[a]{5}$
155	$(\bar{2}2\bar{1})a_1$	3a
156	$(2\bar{2}1)a_1$	3a
157	$(34\bar{1})a_6$	

		$\frac{a}{2}\sqrt{26}$
158	$(3\bar{4}1)a_6$	$\frac{a}{2}\sqrt{26}$
159	$(\bar{1}20)a_1$	$\sqrt[a]{5}$
160	$(\bar{1}\bar{2}0)a_1$	$\sqrt[a]{5}$
161	$(141)a_6$	$\frac{3a}{2}\sqrt{2}$
162	$(1\bar{4}\bar{1})a_6$	$\frac{3a}{2}\sqrt{2}$
163	$(\bar{1}41)a_6$	$\frac{3a}{2}\sqrt{2}$
164	$(\bar{1}\bar{4}\bar{1})a_6$	$\frac{3a}{2}\sqrt{2}$
165	$(\bar{3}4\bar{1})a_6$	$\frac{a}{2}\sqrt{26}$
166	$(\bar{3}\bar{4}1)a_6$	$\frac{a}{2}\sqrt{26}$
167	$(324)a_6$	$\frac{a}{2}\sqrt{26}$
168	$(3\bar{4}\bar{1})a_6$	$\frac{a}{2}\sqrt{26}$
169	$(4\bar{1}\bar{1})a_6$	$\frac{3a}{2}\sqrt{2}$
170	$(4\bar{3}1)a_6$	$\frac{a}{2}\sqrt{26}$

171	$(\bar{4}11)a_6$	$\frac{3a}{2}\sqrt{2}$
172	$(43\bar{1})a_6$	$\frac{a}{2}\sqrt{26}$
173	$(\bar{2}\bar{1}1)a_1$	$\sqrt[a]{6}$
174	$(\bar{2}\bar{2}0)a_1$	$\sqrt[2a]{2}$
175	$(21\bar{1})a_1$	$\sqrt[a]{6}$
176	$(211)a_1$	$\sqrt[a]{6}$
177	$(\bar{2}1\bar{1})a_1$	$\sqrt[a]{6}$
178	$(20\bar{1})a_1$	$\sqrt[a]{5}$
179	$(1\bar{3}2)a_6$	$\frac{a}{2}\sqrt{14}$
180	$(3\bar{3}0)a_6$	$\frac{3a}{2}\sqrt{2}$
181	$(1\bar{3}0)a_6$	$\frac{a}{2}\sqrt{10}$
182	$(\bar{1}\bar{3}2)a_6$	$\frac{a}{2}\sqrt{14}$
183	$(121)a_1$	$\sqrt[a]{6}$
184	$(\bar{1}\bar{2}\bar{1})a_1$	$\sqrt[a]{6}$
185	$(33\bar{2})a_6$	$\frac{a}{2}\sqrt{22}$

186	$(3\bar{3}2)a_6$	$\frac{a}{2}\sqrt{22}$
187	$(130)a_6$	$\frac{a}{2}\sqrt{14}$
188	$(13\bar{2})a_6$	$\frac{a}{2}\sqrt{14}$
189	$(\bar{3}30)a_6$	$\frac{3a}{2}\sqrt{2}$
190	$(132)a_6$	$\frac{a}{2}\sqrt{14}$
191	$(\bar{2}0\bar{1})a_1$	$\sqrt[a]{5}$
192	$(2\bar{1}\bar{1})a_1$	$\sqrt[a]{6}$
193	$(\bar{3}32)a_6$	$\frac{a}{2}\sqrt{22}$
194	$(\bar{3}\bar{1}\bar{2})a_6$	$\frac{a}{2}\sqrt{14}$
195	$(\bar{1}3\bar{2})a_6$	$\frac{a}{2}\sqrt{14}$
196	$(1\bar{3}\bar{2})a_6$	$\frac{a}{2}\sqrt{14}$
197	$(\bar{3}3\bar{3})a_6$	$\frac{a}{2}\sqrt{22}$
198	$(3\bar{1}\bar{2})a_6$	$\frac{a}{2}\sqrt{14}$
199	$(332)a_6$	$\frac{a}{2}\sqrt{22}$

200	$(\bar{3}\bar{3}\bar{2})a_6$	$\frac{a}{2}\sqrt{22}$
201	$(\bar{3}\bar{3}\bar{2})a_6$	$\frac{a}{2}\sqrt{26}$
202	$(\bar{4}\,3\bar{1}0a_6$	$\frac{a}{2}\sqrt{26}$

FCC LATTICE

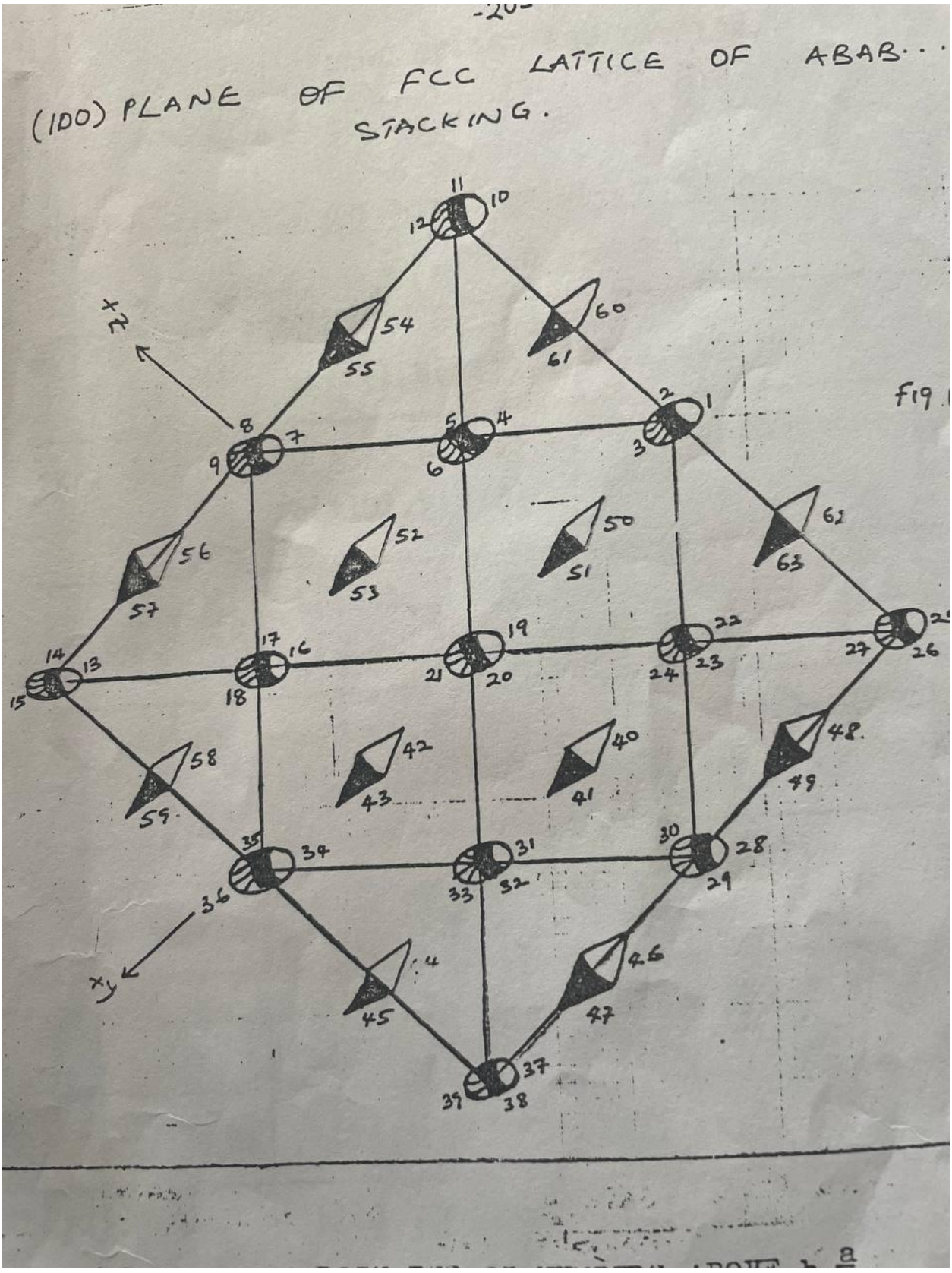
SOME SELECTED POSSIBLE COORDINATES WITH RESPECT TO :A: GIVEN ORIGIN OF AN FCC LATTICE

for (100) plane of an FCC lattice k=x where k=constant. let b= $\frac{a}{2}$

These atomic planes and their coordinates are arranged as shown in the diagram below

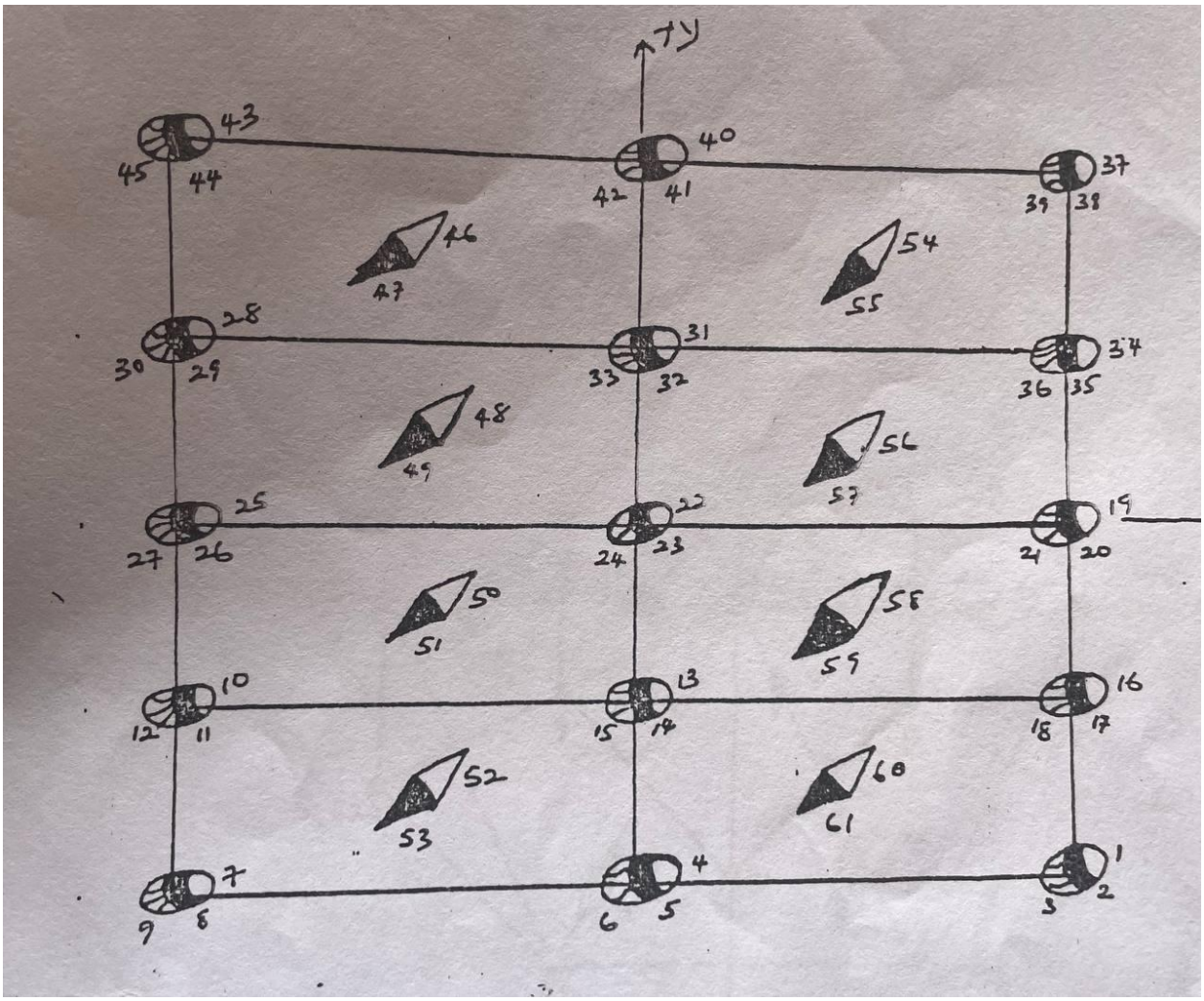
The FCC has it own atoms stacked ABAB into a square net.as shown in the diagram below

K=x=+a	b(200), b(2$\bar{2}$2),b(2$\bar{2}\bar{2}$),b(222),b(22$\bar{2}$),b(20$\bar{2}$), $b(20\bar{2})$, b(2$\bar{2}$0), $b(220)$, b(2$\bar{4}\bar{2}$), $b(24\bar{2})$,b(2$\bar{4}$2),b(240),b(2$\bar{4}$0) b(242)
K=X= $\frac{a}{2}$	b(101),b(10$\bar{1}$),b(1$\bar{1}$0),b(110),b(1$\bar{1}$2),b(1$\bar{1}\bar{2}$),b(112), b(11$\bar{2}$),b(121),b(12$\bar{1}$),b(1$\bar{2}$1),b(1$\bar{2}\bar{1}$),b(14$\bar{1}$),b(1$\bar{4}$1),b(141) b(1$\bar{4}\bar{1}$) b(1$\bar{3}$2),b(1$\bar{3}$0),b(130),b(13$\bar{2}$),b(132),b(1$\bar{3}\bar{2}$)
K=X=0	b(000),b(002),b(00$\bar{2}$),b(011),b(0$\bar{1}\bar{1}$),b(020),b(0$\bar{2}$0),b(01$\bar{1}$) b(0$\bar{1}$1),b(02$\bar{2}$),b(0$\bar{2}\bar{2}$),b(022),b(00$\bar{2}$),b(031),b(0$\bar{3}\bar{1}$), b(03$\bar{1}$),b(0$\bar{3}$1),b(040),b(0$\bar{4}$0),b(04$\bar{2}$),b(0$\bar{4}$2),b(042), b(0$\bar{4}\bar{2}$)
K=x=- $\frac{a}{2}$	b($\bar{1}$0$\bar{1}$),b($\bar{1}$01),b($\bar{1}$10),b($\bar{1}\bar{1}$2),b($\bar{1}\bar{1}$0),b($\bar{1}$1$\bar{2}$),b($\bar{1}\bar{1}$2), b($\bar{1}\bar{2}\bar{1}$),b($\bar{1}\bar{2}$1),b($\bar{1}$2$\bar{1}$),b($\bar{1}$21),b($\bar{1}$30),b($\bar{1}\bar{3}$0),b($\bar{1}\bar{4}$1) b($\bar{1}$4$\bar{1}$),b($\bar{1}$32),b($\bar{1}\bar{3}\bar{2}$),b($\bar{1}$41),b($\bar{1}\bar{4}\bar{1}$),b(1$\bar{3}$2),b($\bar{1}\bar{3}$2), b($\bar{1}$3$\bar{2}$)



For a 110 plane

The arrangement arrangement into planes is shown diagrammatically below, the atoms of the (110) plane of FCC lattice are arranged in a rectangular net with ABAB staking pattern as shown in the diagram below

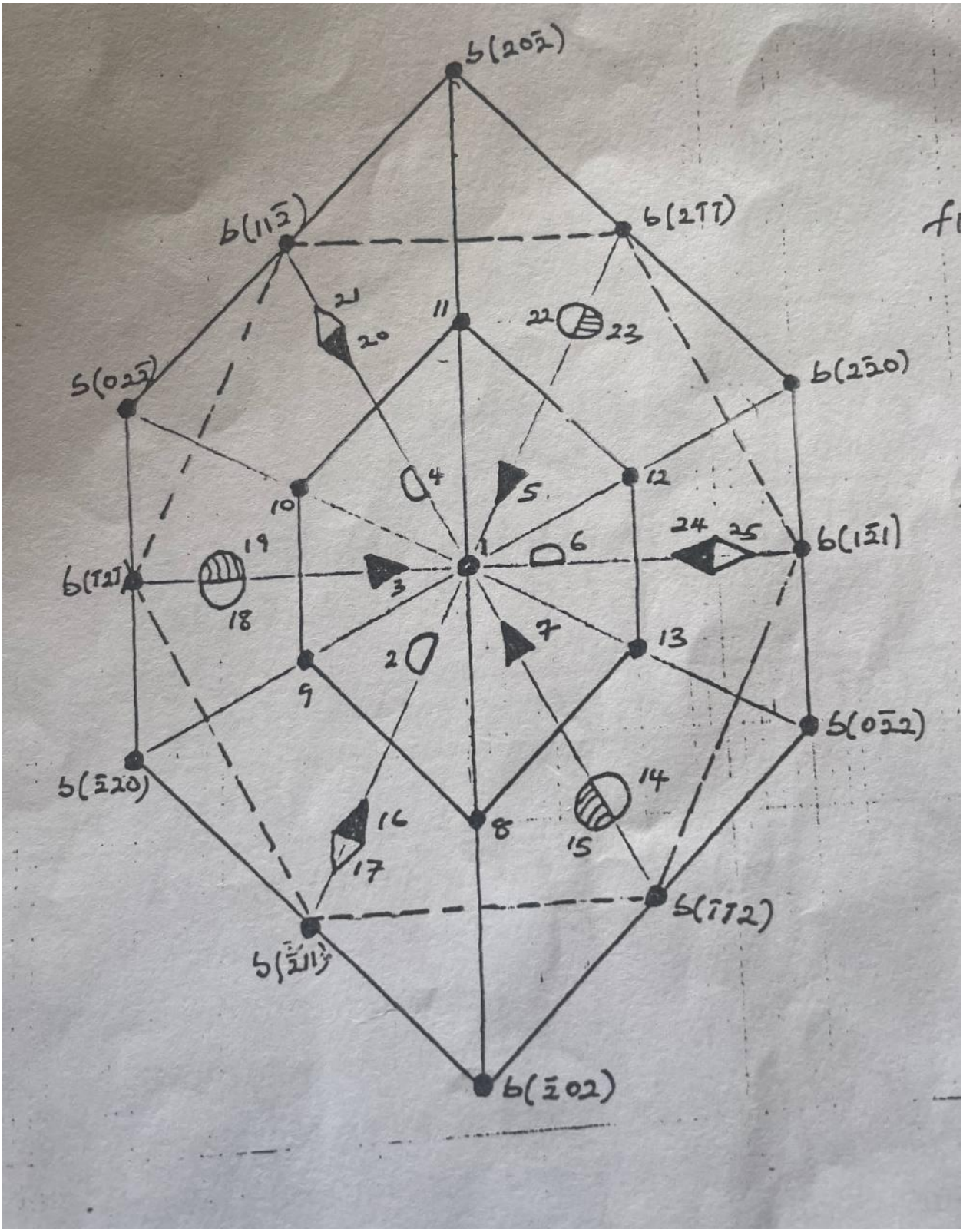


2k=x+y=2a	b(222),b(110),B(22$\bar{2}$),b(220),b(112),b(11$\bar{2}$),b(400), b(040),b(04$\bar{2}$),b(042),b(402),b(40$\bar{2}$)
2k=x+y=+ $\frac{3a}{2}$	b(121),b(12$\bar{1}$),b(21$\bar{1}$),b(211)
2k=x+y=+a	b(200),b(020),b(20$\bar{2}$),b(202),b(02$\bar{2}$),b(022),b(110), b(112),b(11$\bar{2}$)
2k=x+y=+$\frac{a}{2}$	b(101),b(10$\bar{1}$),b(011),b(01$\bar{1}$),b($\bar{1}$2$\bar{1}$),b($\bar{1}$21),b(2$\bar{1}\bar{1}$) b(2$\bar{1}$1)
2k=x+y=0	b(002),b(00$\bar{2}$),b($\bar{2}$2$\bar{2}$),b(2$\bar{2}$2),b($\bar{1}$10),b(1$\bar{1}$0),b($\bar{2}$21) b(2$\bar{2}\bar{2}$),b(1$\bar{1}$2),b($\bar{2}$20),b($\bar{1}$12),b(1$\bar{1}\bar{2}$),b($\bar{1}$1$\bar{2}$), b(6$\bar{6}\bar{4}$),b($\bar{4}$40),b(4$\bar{4}$0).b(4$\bar{4}\bar{2}$),b($\bar{4}$41),b($\bar{4}$4$\bar{2}$),b(4$\bar{4}$2) b(3$\bar{3}$0),b(3$\bar{3}$2),b($\bar{3}$30),b(332),b($\bar{3}$3$\bar{2}$
2k=x+y=-$\frac{a}{2}$	b($\bar{1}$01),b($\bar{1}$01),b(0$\bar{1}\bar{1}$),b(0$\bar{1}$1),b(1$\bar{2}$1),b(1$\bar{2}$1),b(1$\bar{2}\bar{1}$) b($\bar{2}$11),b($\bar{2}$1$\bar{1}$),b($\bar{3}$21),b($\bar{3}$2$\bar{1}$),b(2$\bar{3}\bar{1}$),b(2$\bar{3}$1),b(3$\bar{4}$1) b(3$\bar{4}\bar{1}$),b($\bar{4}$31),b(43$\bar{3}$)
2k=x+y=-a	b($\bar{2}$00),b(0$\bar{2}$0),b($\bar{2}$0$\bar{2}$),b(0$\bar{2}$2),b(2$\bar{4}\bar{2}$),b(2$\bar{4}$2),b(2$\bar{4}$0) b(0$\bar{2}\bar{2}$),b($\bar{1}\bar{1}$2),b($\bar{1}\bar{1}$0),b(0$\bar{2}$1),b($\bar{1}\bar{1}\bar{2}$),b($\bar{4}$20)
2k=x+y=- $\frac{3a}{2}$	b($\bar{1}\bar{2}\bar{1}$),b($\bar{1}\bar{2}$1),b($\bar{1}$2$\bar{1}$),b($\bar{2}\bar{1}\bar{1}$),b(0$\bar{3}\bar{1}$),b(0$\bar{3}$1),b($\bar{3}$0$\bar{1}$) **b(**$\bar{3}$01),b(1$\bar{4}$1),b($\bar{4}$1$\bar{1}$),b(1$\bar{4}\bar{1}$),b($\bar{4}$11)

2k=x+y=-2a	b($\bar{2}\bar{2}$2),b($\bar{2}\bar{2}$0),b($\bar{2}\bar{2}\bar{2}$),b($\bar{4}$00),b(0$\bar{4}$0),b(0$\bar{4}$2),b(0$\bar{4}\bar{2}$) b($\bar{4}$02),b($\bar{4}$0$\bar{2}$)

FOR THE (111) PLANE OF THE FCC LATTICE

3K=X+Y+X, note that b=$\frac{a}{2}$


b(20$\bar{2}$)
b(11$\bar{2}$)
b(2$\bar{1}$1)
21
20
11
22
23
b(2$\bar{2}$0)
b(02$\bar{2}$)
4
5
12
10
24
25
b(1$\bar{2}$1)
19
b(1$\bar{2}$1)
6
1
3
18
2
7
13
9
b(0$\bar{2}$2)
b($\bar{2}$20)
14
16
8
15
17
b($\bar{1}$12)
b($\bar{2}$11)
b($\bar{2}$02)

3k=x+y+z=+3a	b(222),b(042),b(402),b(240),b(420),b(420),b(330), b(312),b(431),b(141),b(341),b(231),b(411)
3k=x+y+z=+2a	b(202),b(022),b(220),b(400),b(040),b(112),b(121) b(211),b(312),b(031),b(301),b(310),b(14$\bar{1}$),b(23$\bar{1}$) b(4$\bar{1}$1),b($\bar{1}$32),b(42$\bar{2}$),b(130),b(422)
3k=x+y+z=a	b(200),b(011),b(020),b(002),b(2$\bar{2}$2),b($\bar{2}$22),b(110), b(22$\bar{2}$),b($\bar{1}$12),b(1$\bar{1}$2),b(12$\bar{1}$),b($\bar{1}$21),b(21$\bar{1}$),b(2$\bar{1}$1) b(31$\overline{2}$),b(03$\bar{1}$),b(04$\bar{2}$),b(30$\bar{1}$),b($\bar{1}$30),b($\bar{2}$31),b(3$\bar{1}$0) b($\bar{3}$41),b($\bar{2}$40),b(4$\bar{3}$1),b($\bar{3}$32)
3k=x+y+z=0	b(000),b(10$\bar{1}$),b(0$\bar{1}$1),b(1$\bar{1}$0),b(20$\bar{2}$),b(0$\bar{2}$2),b(2$\bar{2}$0) b(2$\bar{2}$0),b(11$\bar{2}$),b(1$\bar{2}$1),b(2$\bar{1}\bar{1}$),b(3$\bar{2}\bar{1}$),b(4$\bar{4}$0),b($\bar{2}$4$\bar{2}$) b($\bar{3}$4$\bar{1}$),b(4$\bar{2}\bar{2}$),b(3$\bar{1}\bar{2}$),b($\bar{1}$01),b(01$\bar{1}$),b($\bar{1}$10),b($\bar{2}$02) b(02$\bar{2}$),b($\bar{2}$20),b(11$\bar{2}$),b($\bar{1}\overline{2\bar{1}}$),b($\bar{2}$11),b($\bar{3}$21), $b(\bar{4}40)$ b($\bar{2}$3$\bar{1}$),b(2$\bar{3}$1),b(3$\bar{4}$1),b($\bar{3}$30),b($\bar{1}\bar{3}\bar{2}$)
3k=x+y+z=-a	b(00$\bar{2}$),b(1$\bar{1}\bar{2}$),b($\bar{2}$00), $b(0\bar{1}\bar{1})$,b(0$\bar{2}$0), $b(\bar{1}\bar{1}0)$,b(0$\bar{3}$1) b(1$\bar{1}\bar{2}$),b($\bar{1}$1$\bar{2}$),b($\bar{1}\bar{2}$1),b($\bar{1}$2$\bar{1}$),b(1$\bar{2}\bar{1}$),b($\bar{2}$1$\bar{1}$), $b(\bar{3}2\bar{1})$ b(0$\bar{4}$2),b(3$\bar{3}\bar{2}$),b($\bar{3}\bar{1}$2),b($\bar{4}$20),b($\bar{4}$4$\bar{2}$),b(3$\bar{4}\bar{1}$),b(1$\bar{3}$0) b(2$\bar{2}\bar{2}$),b($\bar{2}\bar{2}\bar{2}$)

3k=x+y+z=-2a	b($\bar{2}0\bar{2}$),b($\bar{2}0\bar{2}$),b(0$\bar{2}\bar{2}$),b($\bar{1}\bar{2}1$),b($\bar{2}\bar{1}\bar{1}$),b($\bar{4}00$),b($\bar{3}1\bar{2}$) b(0$\bar{3}\bar{1}$)_,b($\bar{3}\bar{3}2$),b($\bar{3}\bar{2}1$),b(0$\bar{4}0$),b(2$\bar{4}\bar{2}$),b($\bar{3}0\bar{1}$),b($\bar{2}\bar{3}1$) b($\bar{2}\bar{4}2$),b($\bar{3}\bar{1}0$),b($\bar{4}\bar{1}1$),b($\bar{4}1\bar{1}$),b($\bar{1}\bar{4}1$),b(1$\bar{4}\bar{1}$),b($\bar{4}\bar{2}2$) b($\bar{2}1\bar{1}$),b(1$\bar{3}\bar{2}$).
3k=x+y+z=-3a	b($\bar{2}\bar{2}\bar{2}$),b($\bar{3}\bar{3}0$),b($\bar{4}\bar{4}2$),b($\bar{4}\bar{3}1$),b($\bar{2}\bar{4}0$),b($\bar{1}\bar{4}\bar{1}$),b($\bar{4}\bar{2}0$) b($\bar{2}\bar{4}0$),b($\bar{1}\bar{4}\bar{1}$),b($\bar{3}\bar{4}1$),b($\bar{4}0\bar{2}$),b($\bar{3}\bar{1}\bar{2}$)

FOR THE (210) PLANE OF THE FCC LATTICE

3k=2x+y note that b=$\frac{a}{2}$

planes	Atomic coordinates
2x+y=+3a	b(111),b(11$\bar{1}$),b(220),b(301),b(30$\bar{1}$), b(14$\bar{1}$),b(14$\bar{1}$),b(141),b(2$\bar{1}\bar{1}$)
2x+y=+2a	b(200),b(20$\bar{2}$),b(202),b(121),b(12$\bar{1}$),b(400),b(3$\bar{2}$1), b(040),b(3$\bar{2}\bar{1}$),b(04$\bar{2}$),b(042),b(402),b(12$\bar{1}$),b(120), b(40$\bar{2}$)
2x+y=+ $\frac{3a}{2}$	b(110),b(11$\bar{1}$), $b(112)$, $b(11\bar{2})$,b(2$\bar{1}\bar{1}$),b(2$\bar{1}$1),b(031) b(03$\bar{1}$),b(3$\bar{3}\bar{2}$) b(3$\bar{3}$0),b(3$\bar{3}$2)
2x+y=+a	b(101),b(10$\bar{1}$),b(020),b(1$\bar{1}$1),b(1$\bar{1}\bar{1}$),b(02$\bar{2}$),b(022), b(2$\bar{2}$0),b(4$\bar{2}$2),b($\bar{1}$4$\bar{1}$),b(3$\bar{4}\bar{1}$)

2x+y==+$\frac{a}{2}$	b(011),b(01$\bar{1}$),b(1$\bar{1}$0), $b(1\bar{1}2)$, $b(1\bar{1}\bar{2})$,b($\bar{1}$30),b(2$\bar{3}\bar{1}$) b(2$\bar{3}$1),b(41$\bar{1}$)b($\bar{1}$32),b($\bar{1}3\bar{2}$)
2x+y=0	b(000),b(002),b(00$\bar{2}$),b($\bar{1}2\bar{1}$),b(1$\bar{2}$1),b($\bar{1}$21),b(1$\bar{2}\bar{1}$) b($\bar{2}$42),b(2$\bar{4}\bar{2}$),b(2$\bar{4}$0),
2x+y=- $\frac{a}{2}$	b(0$\bar{1}\bar{1}$),b(0$\bar{1}$1),b($\bar{1}$10),b($\bar{1}$12),b($\bar{1}1\bar{2}$),b($\bar{2}3\bar{1}$)b($\bar{2}$31), b(1$\bar{3}$2)
2x+y=- a	b($\bar{1}0\bar{1}$),b($\bar{1}$01),b($\bar{2}2\bar{2}$),b($\bar{2}$22),b(0$\bar{2}$2),b($\bar{2}$20), $b(0\bar{2}\bar{2})$ b(0$\bar{2}$2),b($\bar{2}$20),b(0$\bar{2}\bar{2}$),b(1$\bar{4}$1),b($\bar{3}$41),b(1$\bar{4}\bar{1}$),b($\bar{3}4\bar{1}$)
2x+y==- $\frac{3a}{2}$	b($\bar{1}\bar{1}$2),b($\bar{1}\bar{1}$0),b($\bar{1}\bar{1}\bar{2}$),b($\bar{1}\bar{2}\bar{1}$),b($\bar{1}\bar{2}$1),b($\bar{2}$11),b($\bar{2}1\bar{1}$) b(0$\bar{3}\bar{1}$),b(0$\bar{3}$1),b($\bar{3}$30),b($\bar{3}$32),b($\bar{3}3\bar{2}$)
2x+y==- 2a	b($\bar{2}$00), $b(\bar{2}02)$,b($\bar{2}0\bar{2}$),b($\bar{3}2\bar{1}$),b(0$\bar{4}$2),b(0$\bar{4}\bar{2}$),b($\bar{4}$40) b($\bar{4}$41),b($\bar{4}4\bar{2}$)
2x+y==- 3a	b($\bar{1}\bar{1}$1), $b(\bar{2}\bar{2}0)$,b($\bar{1}\bar{1}\bar{1}$),b($\bar{3}$01),b($\bar{1}\bar{4}$1),b($\bar{4}$20), $b(\bar{1}\bar{4}\bar{1})$ b($\bar{4}2\bar{2}$)

2x+y+z=+3a	b(202),b(220),b(211),b(042),b(24$\bar{2}$),b(23$\bar{1}$) b(4$\bar{2}$0),b(4$\bar{4}$2),b(4$\bar{1}\bar{1}$),b(4$\bar{3}$1),b(40$\bar{2}$)
2x+y+z=+2a	b(101),b(200),b(1$\bar{1}$1),b(22$\bar{2}$),b(022),b(21$\bar{1}$) b(2$\bar{1}$1),b(031),b(040),b(2$\bar{2}$0),b(2$\bar{4}\bar{2}$),b(41$\bar{1}$) b(4$\bar{2}\bar{2}$)
2x+y=+ $\frac{3a}{2}$	b(110),b(1$\bar{1}$2),b(12$\bar{1}$),b(3$\bar{2}\bar{1}$),b($\bar{1}$32),b(3$\bar{4}$1) b($\bar{1}$41),b($\bar{3}$4$\bar{1}$),b(3$\bar{3}$0),b(13$\bar{2}$),b(3$\bar{1}\bar{2}$)
2x+y+z=+a	b(002),b(011),b(020),b(20$\bar{2}$),b(2$\bar{2}$0),b($\bar{2}$42), b(2$\bar{4}$2),
2x+y=+ $\frac{a}{2}$	b(011),b(01$\bar{1}$),b(1$\bar{1}$0), $b(1\bar{1}2)$, $b(1\bar{1}\bar{2})$,b($\bar{1}$30),b(2$\bar{3}\bar{1}$) b(2$\bar{3}$1),b(41$\bar{1}$)b($\bar{1}$32),b($\bar{1}\bar{3}\bar{2}$)
2x+y=0	b(000),b(002),b(00$\bar{2}$),b($\bar{1}\bar{2}\bar{1}$),b(1$\bar{2}$1),b($\bar{1}$21),b(1$\bar{2}\bar{1}$) b($\bar{2}$42),b(2$\bar{4}\bar{2}$),b(2$\bar{4}$0),
2x+y=- $\frac{a}{2}$	b(0$\bar{1}\bar{1}$),b(0$\bar{1}$1),b($\bar{1}$10),b($\bar{1}$12),b($\bar{1}$1$\bar{2}$),b($\bar{2}\bar{3}\bar{1}$)b($\bar{2}$31), b(1$\bar{3}$2)
2x+y=- a	b($\bar{1}$0$\bar{1}$),b($\bar{1}$01),b($\bar{2}\bar{2}\bar{2}$),b($\bar{2}$22),b(0$\bar{2}$2),b($\bar{2}$20), $b(0\bar{2}\bar{2})$ b(0$\bar{2}$2),b($\bar{2}$20),b(0$\bar{2}\bar{2}$),b(1$\bar{4}$1),b($\bar{3}$41),b(1$\bar{4}\bar{1}$)
2x+y=- $\frac{3a}{2}$	b($\bar{1}\bar{1}$2),b($\bar{1}\bar{1}$0),b($\bar{1}\bar{1}\bar{2}$),b($\bar{1}\bar{2}\bar{1}$),b($\bar{1}\bar{2}$1),b($\bar{2}$11),b($\bar{2}$1$\bar{1}$), b(0$\bar{3}\bar{1}$),b(0$\bar{3}$1),b($\bar{3}$30),b($\bar{3}$32),b($\bar{3}\bar{3}\bar{2}$)

2x+y+z=-2a	b($\bar{2}$00),b($\bar{2}$02),b($\bar{3}$21),b(0$\bar{4}$0),b($\bar{3}$2$\bar{1}$),b(0$\bar{4}$2),b(0$\bar{4}\bar{2}$) b($\bar{4}$40),b($\bar{4}$41),b($\bar{4}\bar{4}\bar{2}$)
2x+y+z=-3a	b($\bar{1}\bar{1}$1),b($\bar{2}\bar{2}$0),b($\bar{1}\bar{1}\bar{1}$),b($\bar{3}$01),b($\bar{1}\bar{4}$1),b($\bar{4}$20),b($\bar{1}\bar{4}\bar{1}$) b($\bar{4}\bar{2}\bar{2}$)

(211) crystallographic plane

2x+y+z=+3a	b(202),b(220),b(211),b(042),b(24$\bar{2}$),b(23$\bar{1}$), b(4$\bar{2}$0),b(4$\bar{4}$2),b(4$\bar{1}\bar{1}$),b(4$\bar{3}$1),b(40$\bar{2}$)
2x+y+z=+2a	b(101),b(200),b(1$\bar{1}$1),b(22$\bar{2}$),b(022),b(21$\bar{1}$), b(2$\bar{1}$1),b(031),b(040),b(2$\bar{2}$0),b(2$\bar{4}\bar{2}$),b(41$\bar{1}$) b(4$\bar{2}\bar{2}$)
2x+y+z=+a	b(002),b(011),b(020),b(20$\bar{2}$),b(2$\bar{2}$0),b($\bar{2}$42) b(2$\bar{4}\bar{1}$)
2x+y+z=0	b(01$\bar{1}$),b(0$\bar{1}$1),b($\bar{2}$22),b(2$\bar{2}\bar{2}$),b(02$\bar{2}$),b(0$\bar{2}$2), b($\bar{2}$31),b(2$\bar{3}\bar{1}$), $b(\bar{2}40)$
2x+y+z=-a	b(00$\bar{2}$),b(0$\bar{1}\bar{1}$),b(0$\bar{2}$0),b($\bar{2}$02),b($\bar{2}$20),b(0$\bar{4}$2) b($\bar{2}$3$\bar{1}$),b($\bar{2}\bar{4}\bar{2}$)
2x+y+z=-2a	b($\bar{1}$0$\bar{1}$),b($\bar{2}$00),b($\bar{1}$1$\bar{1}$),b($\bar{1}\bar{1}$1),b(0$\bar{2}\bar{2}$),b($\bar{2}\bar{1}$1) b($\bar{2}$1$\bar{1}$),b($\bar{2}$1$\bar{1}$),b(0$\bar{3}\bar{1}$),b(0$\bar{4}$0),b($\bar{4}$40),b($\bar{4}$31)

2x+y+z=-2a	b($\bar{2}0\bar{2}$),b($\bar{2}\bar{2}0$),b($\bar{2}\bar{1}1$),b($\bar{4}20$),b($\bar{4}4\bar{2}$),b($\bar{4}$110, b($\bar{4}3\bar{1}$)
2x+y+z=-3a	b($\bar{2}0\bar{2}$),b($\bar{2}\bar{2}0$),b($\bar{2}\bar{1}\bar{1}$),b(0$\bar{4}\bar{2}$),b($\bar{4}$02),b($\bar{2}\bar{3}$1) b($\bar{2}\bar{4}2$),b($\bar{4}20$),b($\bar{4}4\bar{2}$),b($\bar{4}$11),b($\bar{4}3\bar{1}$)

(221) crystallographic planes

2x+2y+z=+3a	b(22$\bar{2}$),b(202),b(022),b(112),b(31$\bar{1}$),b(04$\bar{2}$), b(32$\bar{1}$),b(4$\bar{2}$2),b($\bar{1}$32),b(40$\bar{2}$),b(13$\bar{2}$)
2x+2y+z=+2a	b(200),b(020),b(220),b($\bar{1}$30),b(3$\bar{1}$0),b($\bar{2}$40)
2x+2y+z=+a	b(002),b(2$\bar{2}$2),b($\bar{2}$22),b(20$\bar{2}$),b(02$\bar{2}$),b(1$\bar{1}$2),b(11$\bar{2}$) ($\bar{2}$2$\bar{1}$),b(4$\bar{4}$2),b(3$\bar{3}$2),b($\bar{3}$32),b($\bar{1}$3$\bar{2}$),b(3$\bar{1}\bar{2}$)
2x+2y+z=0	b(000),b($\bar{1}$20),b(1$\bar{1}$0),b($\bar{2}$11), b($\bar{3}$21),b($\bar{4}$31)
2x+2y+z=-a	b(00$\bar{2}$),b(2$\bar{2}$2),b(2$\bar{2}\bar{2}$),b($\bar{2}$02),b(0$\bar{2}$2),b(1$\bar{1}\bar{2}$), b($\bar{1}$1$\bar{2}$),b($\bar{3}$12),b(3$\bar{3}\bar{2}$),b(2$\bar{4}$2),b($\bar{4}$4$\bar{3}$),b(1$\bar{3}$2),b($\bar{3}$32)
2x+2y+z=-2a	b($\bar{2}$00),b(0$\bar{2}$0),b($\bar{1}\bar{1}$0),b($\bar{4}$40),b(2$\bar{4}$0),b(4$\bar{2}$0),b(1$\overline{30}$)
2x+2y+z=-3a	b($\bar{1}\bar{1}$1),b(0$\bar{2}\bar{2}$),b($\bar{1}\bar{1}\bar{2}$),b($\bar{3}\bar{1}$2),b(2$\bar{4}\bar{2}$),b($\bar{4}$02)

(311)

3x+y+z=+2a	b(101),b(110),b(20$\bar{2}$),b(022),b(1$\bar{1}$2),b(2$\bar{2}$0),b(12$\bar{2}$) b(12$\bar{1}$),b(2$\bar{1}\bar{1}$),b(031),b(040),b(3$\bar{3}$2),b(2$\bar{3}$1),b($\bar{3}$41) b(3$\bar{4}\bar{1}$),b(13$\bar{2}$)
3x+y+z=+a	b(002),b(10$\bar{1}$),b(011),b(020),b(1$\bar{1}$0), $b(1\bar{1}\bar{1})$, b(11$\bar{2}$),b(1$\bar{2}$1),b(03$\bar{1}$),b(04$\bar{2}$),b(2$\bar{3}\bar{1}$),b($\bar{1}$32),b(4$\bar{4}$1), b(1$\bar{3}$2)
3x+y+z=0	b(000),b(01$\bar{1}$),b(0$\bar{1}$1),b(02$\bar{2}$),b(0$\bar{2}$2),b($\bar{1}$12),b(1$\bar{1}\bar{2}$) b($\bar{1}$21),b(1$\bar{2}\bar{1}$),b($\bar{2}$42),b(2$\bar{4}\bar{2}$),b($\bar{1}$30),b(1$\bar{4}$1),b($\bar{1}\bar{4}\bar{1}$), b(1$\bar{3}$0)
3x+y+z=-a	b(00$\bar{2}$),b(0$\bar{2}$0),b($\bar{2}\bar{2}\bar{2}$),b($\bar{1}$10),b($\bar{2}$22),b($\bar{1}\bar{1}$2),b(0$\bar{3}$1), b(0$\bar{4}$2),b($\bar{2}$31),b($\bar{2}$40),b(1$\bar{4}\bar{1}$),b($\bar{1}\bar{3}\bar{2}$)
3x+y+z=-2a	b($\bar{3}$32),b($\bar{2}\bar{4}\bar{2}$),b($\bar{2}\bar{3}\bar{1}$),b(0$\bar{4}$0),b(0$\bar{3}\bar{1}$),b($\bar{2}$11),b($\bar{1}\bar{2}$1) b(0$\bar{2}\bar{2}$),b($\bar{2}$02),b($\bar{1}\bar{1}$0),b(0$\bar{1}\bar{1}$),b(20$\bar{1}$)

(320) crystallographic plane

3x+2y=+3a	b(200),b(20$\bar{2}$),b(202),b(031),b(03$\bar{1}$),b(4$\bar{3}$1)
3x+2y=+2a	b(002),b(020),b(02$\bar{2}$),b(022),b(2$\bar{1}\bar{1}$),b(2$\bar{1}$1),b(4$\bar{4}$0), b(4$\bar{4}\bar{2}$),b(4$\bar{4}$2),b(3$\bar{4}$1)
3x+2y=+ $\frac{3a}{2}$	b($\bar{1}$3$\bar{2}$),b($\bar{3}$30),b(3$\bar{3}$2),b(3$\bar{3}$0),b($\bar{1}$32),b(130),b(3$\bar{3}\bar{2}$) b(10$\bar{1}$),b(101)
3x+2y=+a	b(011),b(01$\bar{1}$),b(2$\bar{2}$0),b($\bar{1}$21),b($\bar{2}$4$\bar{2}$),b($\bar{1}$20)
3x+2y=+ $\frac{a}{2}$	b(1$\bar{1}$0),b(1$\bar{1}$2),b(1$\bar{1}\bar{2}$),b($\bar{1}$2$\bar{1}$),b($\bar{1}$21),b($\bar{3}$41),b(3$\bar{3}\bar{1}$)
3x+2y=0	b(2$\bar{3}$1),b(2$\bar{3}\bar{1}$),b($\bar{2}$31),b(000)
3x+2y=- $\frac{a}{2}$	b($\bar{2}$2$\bar{2}$),b($\bar{1}$10),b($\bar{1}$12),b($\bar{1}$1$\bar{2}$),b(1$\bar{2}$1),b(1$\bar{2}\bar{2}$),b($\bar{3}$4$\bar{1}$)
3x+2y=- a	b(2$\bar{4}$0),b(2$\bar{4}$2),b(2$\bar{4}\bar{2}$),b($\bar{1}$10),b($\bar{2}$22),b(0$\bar{1}$1),b(0$\bar{1}\bar{1}$)
3x+2y=- $\frac{3a}{2}$	b($\bar{1}$0$\bar{1}$),b($\bar{1}$01),b($\bar{2}$02),b($\bar{2}$3$\bar{1}$),b(1$\bar{3}$2),b(2$\bar{3}$0),b(1$\bar{3}\bar{2}$) b($\bar{3}$3$\bar{2}$)
3x+2y=-2a	b(00$\bar{2}$),b(0$\bar{2}$0),b(0$\bar{2}$2),b(0$\bar{2}\bar{2}$),b($\bar{2}$11),b($\bar{2}$1$\bar{1}$),b($\bar{4}$40) ($\bar{4}$40),b($\bar{4}$41),b($\bar{2}$2$\bar{1}$)
3x+2y=-3a	b($\bar{2}$00),b($\bar{2}$0$\bar{2}$),b(03$\bar{1}$),b($\bar{4}$3$\bar{1}$),b($\bar{4}$3$\bar{1}$)

CHAPTER FOUR

RESULTS AND DISCUSSION

The FCC lattice researched in this work reveal the following information

PLANES	LATTICE STRUCTURE	STACKING PATTERN	SURFACE AREA
(100)	square net	ABAB...	a^2
(110)	rectangular net	ABAB....	$a^2\sqrt{2}$
(111)	Hexagonal	ABCABC..	$a^2\sqrt{3}$ or $1.7321a^2$
(210)	Rectangular	ABBCCA...	$a^2\sqrt{6}/2$
(211)	Hexagonal	ABBCCA...	$a^2\sqrt{6}/2$ or $1.2247a^2$
(221)	Rectangular	AABBCCDD...	$3a^2$
(310)	Rectangula	ABCBCABACBCA...	$a^2\sqrt{10}/2$ or$1.5811a^2$
(311)	Hexagonal	ABCBACABCAB...	$a^2\sqrt{11}$ or $3.3166a^2$
(320)	Rectangular	ABCCBAABCCBA..	$a^2\sqrt{13}$ or $3.6056a^2$

The above following information shows the lattice structure, stacking pattern which repeats every two layers and the surface area of various planes with A,B,C and D representing the positions of the atoms in various planes.

Next nearest neighbor

4.2 THE NEAREST NEIGHBORS OF fCC LATTICE

NN=Nearest Neighbor

NNN=Next Nearest Neighbor

Note b=$\frac{a}{2}$

1.NN=12NN = b(±1±10)

2.NN=6NN=b (±200)

3.NN=24NN=b(±1±1±2)

4.NN=12NN=b(±20±2)

5.NN=16NN=b(±10±3)

6.NN=8NN=b(±2±2±2)

7.NN=32NN=b(±3±2±1)

8.NN=4NN=b(±400)

9.NN=20NN=b(±3±30)

10.NN=16NN=b(±4±20)

11.NN=8NN=b(±3±3±2)

12.NN=16NN=b(±2±4±2)

13.NN=16NN=b(±4±3±1)

14.NN=4NN=b(±4±40)

15.NN=8NN=b(±4±4±2)

CHAPTER FIVE

FINDINGS, CONCLUSION, CONTRIBUTION TO KNOWLEDGE AND SUGGESTIONS FOR FURTHER STUDIES

FINDINGS; The following are the findings of this project;

1. The atomic coordinates or positions and their distance of 202 atoms of FCC.
2. The next nearest neighbors up to the 15th
3. The arrangements of these atoms into various planes, from the low index (100) to the high index (311)

CONCLUSION:

The crystallographic arrangements of FCC lattice structure into planes have been successfully analyzed and virtualized. The study revealed the atomic positionings and arrangements within the BCC lattice structure, providing valuable insights into its crystallographic properties.

CONTRIBUTION TO KNOWLEDGE

This research has contributes to the existing knowledge on crystallography by following

1. It has provided a detailed analysis of the FCC lattice structure and its atomic arrangements.

2. It visualizes the crystallographic planes within the FCC lattice structure.

3. It has enhanced the understanding of the crystallographic properties of FCC lattice structures

SUGGESTIONS FOR FURTHER STUDIES

further studies can be carried out in the following areas in order to enhance a broader understanding

1. Investigate the crystallographic properties of other structures like the HCP, SCC, BCC.

2. Analise the effects of defect and inpurities on the crystallographic properties of FCC lattice structures

3. Explore the applications of crystallography in material science and engineering, such as in the development of new materials and technologies

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