Hello
Programme sybsc
subject physics
semister 4 whose code is pyc 104

section
2 modern physics & optics
modern physics unit one modern physics
module name crystal lattice
unit cells
crystal planes
and miller indices of typical crystal
structure
outline of this course is crystal
lattice unit cells crystal planes
and
miller indices typical crystal structure
after learning this
the students will be able to explain the
crystal lattice unit cells, crystal
planes and miller indices. students will
be able to draw the crystal structure
and
explain crystal lattice
crystal :-crystal is a solid, whose atoms are arranged in a
highly ordered repeating pattern thesepatterns are called as crystal system
crystal lattice
crystal lattice is a symmetrical
three-dimensional structural arrangement
of atoms ions or molecules inside a
crystalline solids .
crystal lattice can also be defined as
the geometrical arrangement of atoms of
the crystalline solids as points in
space
unit cell :-the smallest
repeating unit of crystal lattice is a
unit cell
the different types of unit cells are
first one simple cubic crystal structure unit cell
second one body centered cubic crystal
structure unit cell
third one :-centered cubic
crystal structure unit cell
first one
simple cubic crystal structure unit cell
here there are eight corner atoms one
two three four five six seven eight.
In a simple cubic crystal structure unit cell the atoms
are present only at the corners .every
atom at the corner is shared among eight
adjacent unit cells there are four unit
cells in the same layer and four in the
upper or lower layer therefore simple cubic
crystal structure has only one eighth of an atom in a simple cubic
crystal structure. there are eight as
atoms at the corners therefore the total
number of atoms in the simple cubic
crystals structure unit cell is
one by eight into eight is equal to one.
in case of body centered cubic crystal
structure
there are eight atoms at the corners and
one on the body
therefore body centered cubic crystal
structure has atoms at each corner of
the cube and one atom at the corner of
the structure therefore the total number
of atoms in the body
centered cubic crystal cell is eight
corners into one by eight per atom and
corner per atom is equal to one one body
center atom that is one into one
therefore the total number of atoms is one plus one is equal to 2
phase centered cubic crystal structure
so here there are 8 corner atoms
1 2 3 4
and then
5 6 7 8 and six phase atoms you can see
here .one

two
three
four five and six
these are the six
phase atoms in face centered cubic
crystal structure the atoms are at the
corners of the crystal and at the center
of all the faces of the cube the atoms
present at the face centered is shared
between two adjacent unit cells
and only half of each atom belong to
individual cell therefore the number of
atoms in fcc unit cell is eight corner
atoms into one by eight per corner atom
is equal to one atom and
six face centered atoms into half atom per unit cell this is six into one by
two is equal to three atoms therefore
the total number of atoms in fcc face
centered cubic crystal structure is one
plus three is equal to four atoms
crystal planes.
crystal planes are defined as some
imaginary planes inside a crystal in
which large concentration of atoms is
present
inside a crystal there exists a certain
directions along which large
concentration of atoms exist these
directions are called as crystal
directions.
miller indices a latticeplane is a plane
which passes through any three points
which are not in a straight line
a set of parallel lattice planes
h k l divides a into h part b into k part and c into l parts
where a b c are the lengths of the unit
cell sides
so you can see here this is divided
this is the center a by h b by k and
c by l z axis is divided to c by l y
axis is divided into b by k x is divided
into e by h
the indices of the line h k i l are
defined therefore the line intercepts r
a at a by h b at b by k and c at c by l
find the intercepts of the plane on 3x
defined by the
basis vectors abc to get three numbers
n1 and n2 and n3 take the reciprocals of
n1 and n 2 and n3. third one divide the reciprocals by
the greatest common divisor the
resulting set of three numbers hkl is
called as miller indices of for the
plane hkl
rules for determining miller indices
determine the intercepts of the phase
along the crystallographic axis in terms
of
unit cell dimensions take the
reciprocals clear fractions reduce the
lowest
term we want to find out the miller
indices of plane this is the example
binding layer indices of a plane whose
intercepts are a b and c draw the plane
intercepts abc
intercept length
is
one reciprocals
one one one lcm will be
one greatest common divisor of the
reciprocal is one one one therefore the
mirror indices of a plane is one one one
diagram of the plane abc you can see
here this is the x-axis y-axis z-axis
this plane goes through x-axis
so
a
and
y-axis

is in parallel with this
zx is in parallel so a 0 0 at this on
the x axis y term is on
on y axis and z is in parallel with this
x is in parallel so 0 is 0
again z axis is 0 0 e intercepts are a b
c reciprocals a by 1 b by 1 c by 1 so
respirators is 1 1 1 miller indexes of h
k l is 1 1 1 you can see this 1 1 1
plane reference to the origin oh origin
ooh so from the origin o this x-axis is
in it is it it is it goes through x-axis it
goes through y-axis it goes through axis
if it is with the origin it goes to the
x axis it goes through y axis it goes
through z axis it goes to
x axis it goes through y axis it goes
through z axis this is a 1 1 1 plane
1 1 0 plane reference to the origin at
point o this is the origin here this is
origin origin so here one one one plane x axis goes
through origin y axis goes through origin y y-axis goes
through origin and z-axis is in parallel with this so you
can see here miller indices for the planes crystal planes are
in given in green which has infinite number
of parallel planes each has a
consistent distance a away from the
origin here the plane intersects the
x-axis plane intersects the x-axis at
point a and it is parallel to y and parallel to
z axis here the plane can be designated
as one zero zero plane one zero zero plane so for three planes
can be designated as 0 this is 1 in finite
it is in parallel with the y axis it is
in parallel with the z axis one infinite
and infinite and this is
infinite upon infinite plane here
this is in parallel with the wire it
goes through y axis parallel to
x axis and parallel to z axis this is
infinite infinite one plane
so it is in it goes through z axis it
goes through z axis parallel to x-axis
parallel to y-axis miller industries are
reciprocals of the parameters of each
crystal plane here green
as miller and dice is one zero zero
yellow
has miller indices 0 1 0 and again green
has miller indices 0 0 1 plane find the
miller indices of the plane 2 a minus 3
b minus 2 c
solution intercepts are 2 minus 3 minus
2 reciprocals of the intercepts are 1 by
2
1 by minus 3 and 1 y minus 2 sum of 2 3
and 2 is 6 therefore miller indices of
this plane is 3 minus 2 and minus 3.
separation between the lattice planes in
the cubic crystal
the cube edge
is a let hkl be the miller indices of a
plane abc this plane belongs to the
family of play
plane whose miller dice is r h k l
because miller indices represent the set
of planes let o n is equal to d
be the perpendicular distance of the
plane abc from the origin let alpha beta
gamma be the angle between the
coordinate x is x y z respectively you
can see here this is a plane alpha is
the angle beta is the angle gamma is
angle d is the distance between o n is
normal d is the distance of the normal x
axis y-axis and z-axis abc is a
inter plane so the intercepts of the
plane on the three axis are
oa is equal to you can see there o
ob and oc y is equal to a by h o b is

equal to a by k and oc is equal to
a by l from the figure a first figure
from the figure a cos alpha is equal to
d by o a cos beta is equal to d by op
and cos gamma is equal to d by oc
therefore
cos alpha is to cos beta is is to cos
gamma is equal to
d by
a i can write it as a by h
is to d by ob ob i can write it as a by
k is to d by
oc you see i can write it as a by l
from the law of
directions of cosines we can write it as
cos square alpha plus cos square beta
plus cos square gamma is equal to 1
therefore
d square s square by a square plus d
square k square by a square plus d
square l square by a square is equal to
1 take common from this d square by is
very common s square plus k square plus
l square is equal to 1 that is d square
is equal to a square by s square plus k
square plus l square therefore d is
equal to a upon square root of s square
plus k square plus l square from
equation three gives the distance of
separation between the successive planes
of a simple cubic crystal structure
example the lattice constant of a cubic
lattice
is
a calculate the spacing between 0 1 1
1 0 1 and 1 1 2
please so we know that
d h k l is given by the expression d is
equal to 1 upon square root of s square
by square plus k square by l square and
b square plus l square by c square
in the case of cubic lattice is is equal
to b is equal to c is equal to e
therefore d is equal to a upon square
root of s square plus k square plus l
square that is d of h k l is equal to a
upon
square root of s square plus k square
plus l square
d of 1 1
1 plane is d upon square root of a
square plus 1 square plus 0 square plus
1 square plus 1 square this is a by root
2 d of 1 0 1 is a by root 2 d of 1 1 2
is a by root 6
the references used here
is solid state physics by c kittle
and
next one is fundamental of solid state
physics by
saxena
thank you
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