welcome dear students to the fourth
module of the paper
GEC 105 Mineralogy
we are going to study about the
extensive variables
intensive variables and the degrees of
freedom that are required to define
a system.
At the end of the lecture
you will be able to define and
understand
Extensive and intensive variables and
degrees of freedom
and also be able to calculate the
degrees of freedom of a system.
What are variables? to define the state
of a system
completely, the variables of the system
must be known.
these variables can be extensive to the
system
or they can be intensive to the system.
extensive variables depend on the
quantity of material in the system
for example the mass of the components
the mass of the system
the volume of the system. These are not
intrinsic to the system and do not
affect the macroscopic properties,
for example 10, 20 grams of water
and 50 grams of water. but we are looking
at water itself.
its composition doesn't change whether
its mass is 20 grams or its
mass is 50 grams. Such variables
are extensive to the system.
Intensive variables are properties of the
substances
that compose a system. These are
pressure, temperature, and bulk composition
of the phases present. These intensive
variables
may be independent to a certain degree
for example at one atmosphere
water will be in liquid phase between 0
degree celsius to
200 degree celsius. So in this range

the pressure and temperature variables
are independent of each other
that is between 0 degree celsius - 200
degree celsius
i can slightly alter the pressure and
the water will remain in liquid state
or at one atmospheric pressure i can
increase the temperature from one degree
celsius to 99 degrees celsius
and I will still have liquid water. It
does not change the state of the system.
These variables are independent
but where liquid water and vapor are in
equilibrium
that is at its boiling point that is
hundred degree celsius
the temperature is fixed for one
atmospheric pressure
and we know that the boiling point of
water is 100 degree celsius.
now if i have to slightly increase the
pressure
of the system the boiling point of water
will no longer be hundred degree celsius
it will go up to about 102 degrees
celsius.
hence temperature and pressure
are dependent here.
So these two variables at the boiling
point of water are dependent on each
other.
So a slight change in pressure, the
temperature will
also have to be changed. For equilibrium
system if we increase the temperature
at one atmospheric pressure the liquid
phase of water will disappear
and you will only have vapor so here
the phase is changing. Similarly
if we increase the pressure the boiling
point of water will also increase
and it will only have liquid water at
100 degrees celsius,
just as we have discussed earlier.
Now the question that arises is,
how many such intensive variables do we
have to completely

specify before the other variables
are constrained or they fall in place
and the state of the system
is known?
This is given by the term degrees of
freedom.
Now, if you remember the gibbs phase rule
it states that the number of phases
represented by P plus the number of
degrees of freedom,
represented by F, is equal to the number
of components plus
two so the number of degrees of freedom
of a system is defined as the minimum
number of
intensive variables that need to be
specified to completely define
the state of the system at equilibrium.
Now the gibbs phase rule can be
rewritten
as F is equal to C
minus P plus 2 since we have transferred
P from this side of the equation to the
other side, the number of degrees of
freedom
is equal to number of components minus
the number of phases
plus two. This phase rule
applies only to chemical systems that
are in equilibrium.
The degrees of freedom in a geological
system
are in fact the bulk composition
or concentration of components, the
pressure
and the temperature of the system. These
variables need to be fixed
in order to define the conditions of the
system.
If one knows the number of components
and phases
the degrees of freedom can be easily
calculated
by substituting the number of components
and phases in this system.
So, if we have two components and two
phases in a system

so we can substitute two phases and two components here.
so it will be two minus two plus two
Hence calculating the degrees of freedom will be equal to
two.
In a single phase of pure substance, for example
plagioclase, you have the degree of freedom equal to two
for a glass of liquid water if we specify one of the independent intensive variable to be pressure say we specify
pressure to be one atmosphere the temperature can take
any value between zero degree celsius and hundred degree
celsius for one atmosphere. Within this range
the temperature can be chosen independently of the pressure.
Thus both pressure and temperature are independent. But once you choose the temperature
and pressure pair, any other properties such as volume or entropy can be found using the steam tables or mollier diagrams.
Therefore, the remaining properties cannot be independently chosen
after temperature and pressure is specified
for two co-existing phases of pure substance.
now here your phases will be two
and the components will be
1. So 1 minus 2 plus 2
you will get 1.
so the degrees of freedom that you will get here will be
1. Now in a glass of boiling water
in equilibrium with saturated steam
that is we are looking at 100 degree celsius for one atmospheric pressure
one of the independent intensive variables

is pressure then the temperature must be
100 degree
celsius for the boiling point of water
to be reached.
that is hence for water and steam
to be coexisting in the system the
temperature
should be 100 degree celsius for one
atmosphere pressure.
hence temperature cannot be chosen
independently of the pressure.
Thus only pressure is independent
the temperature required at other
pressures as well as the values of all
remaining thermodynamic properties can
be found again
in steam tables or mollier diagrams.
so here the degree of freedom is equal
To one.
For three coexisting phases of pure
substances,
the degree of freedom will be zero.
At this we have a triple point in the
system.
This triple point represents vapor,
liquid and solid, all coexisting
together. At this point for any given
substance,
the triple point occurs only at one
specific
pair of pressure and temperature. Slight
change in temperature
the triple point disappears. Slight change
in pressure, the triple point disappears.
So once it is stated that the substance
is at the triple point,
the values of temperature and pressure
pair
cannot be changed. Thus no thermodynamic
property can be chosen
Independently..
For this lecture you can
Refer to the
books Mineralogy by Dexter Perkins
Manual of Mineral Science by Klien P Dutrow and Igneous and Metamorphic
petrology by Winter
Thank You!