ok welcome to the second lecture of thermodynamics in which as usual we shall start with ah recapitulation so we discussed thermodynamic variables which are macroscopic objects measurable in experiments there are of two types one is extensive and other intensive extensive thermodynamic variables are indicative of the system size for example number of particle volume internal energy later we will introduce probably concept of free energy entropy these are extensive variables they are indicative of the system size if we double the size of the system maintaining equilibrium these quantities will be doubled on the other hand pressure temperature these are intensive variable these quantities do not depend on the system size okay insensitive to the system size they are fixed by the equilibrium condition similarly if i have density which is n over v this quantity is an intensive quantity even though n is extensive and so is v

so these extensive and intensive variables are my thermodynamic variables which describe a system but the system which i am considering is always interacting with a reservoir or we called it the rest of the universe or simply the universe

so system separated from the universe by walls we talked about different type of walls for example adiabatic wall which does not allow any heat exchange or diathermic wall where i can have heat exchange in general i can have both heat exchange and mechanical interaction

so system universe and system is separated from the universe by wall system is small whereas reservoir is very very big i can assume that heat capacity is in finite which i mean by saying that if i extract heat from this or wire or i release some heat to the reservoir its temperature does not change ok

so as i said walls are diathermic and adiabatic in general we will consider walls which are diathermic and also movable

so that i can do some mechanical work on the system on the other hand system can also do some mechanical work on its own on the universe

so do two types of interactions i mentioned mechanical and thermal there could be other type of interactions for example there could be particle exchange which we are not interested in in the present set of lectures then the concept of equilibrium ok equilibrium means all the thermodynamic variables we measure do not depend on time this is an idealized concept all these walls there is no perfect adiabatic wall in this universe ok this is an idealized concept similarly equilibrium is an idealized concept ok i would rather say i define equilibrium within the time scale of my experiment as long as i am doing experiment on the system the thermodynamic variables pressure temperature which i measure they do not depend on time to maintain the equilibrium whatever change i will do is a quasi static change quasi static change means its a very very slow change which means its lower than all other time scales of the problem i can assume that every instant of time my system is in equilibrium i can describe if i have an ideal gas rather one mole of ideal gas i can describe it through the equation of state pv is equal to rt at every instant of time that explains what i mean when i plot a pv diagram if i plot p as a function of v i get a pv diagram which says at every instant of time i am in equilibrium i can write p v is equal to rt okay so quasi static process is very very important to maintain equilibrium and since i am maintaining equilibrium at every instant of time i can write the equation of state ok this is brief recapitulation what i did the concepts of thermodynamics i repeat its a macroscopic subject but eventually the results what we get at the end of the day will be same as those which we obtained from kinetic theory of gas ok let us proceed so i proposed first law of thermodynamics for you is a conservation of energy so i can have a situation where i have my system and i give some energy to the system in the form of it so i provide an energy which i will call thermal energy amount delta q or i use this notation delta q whenever i write tilted delta or q delta it represents an infinite decimal change let me call its a finite change but let me not bother about this nitty gritty details we use these two notations almost interchangeably ok so i supply delta q amount of heat to the system and if i do not allow the system to do any mechanical work some quantity must increase and that we call the internal energy internal energy must increase because energy cannot be dissipated if energy cannot be dissipated some quantity must increase and that is the internal energy let us say we have ideal gas and it is the internal energy of the ideal gas that will actually increase if i provide delta q similarly if i have a system and i push this wall of the container i am doing some mechanical work on the system i am doing some mechanical work i will always assume there is no friction there is no dissipation that means all i am doing is conservative ok ok if i

do some work again there will be
increase in internal energy because i am not allowing any heat exchange these two are
the extreme situations which tells me that i have to bother about three quantities one i
have already written delta q that is heat exchange and then mechanical work delta w and i mentioned
something something like a ghost that appears in our theory now that is the internal energy which i
write as delta u ok which i write as d u
so i have delta q delta w and delta u the first
law of thermodynamics which is nothing but the conservation of total energy
will involve these three quantities this should be very very clear
so i must take
into account the internal energy will restrict to two hypothetical extreme situations in which one
of them i have only heat exchange in the other i only have mechanical work ok having said this we
proposed the first law of thermodynamics delta q is the heat supplied to the system delta w is work
done by the system
so delta q should be equal to delta u plus delta w
so whatever heat i supply
to the system will be dissipated in two forms or will be used in two forms one is system will do
some work
so this is the work done by the system work done as i have written already let
me write it again work done by the system and this is the increase in internal energy
so this is how i propose my first law of
thermodynamics all these three quantities delta q delta w and delta u they should be
put together to get a conservation of energy now if you look at this equation first
extreme case was no delta w
so case one which we studied in the previous
slide there is no delta w
so you see delta q is equal to delta u
that is what i was trying to emphasize that if there is no work done by the system
this whole heat i have supplied to the system goes into increasing the
internal energy of the system on the other hand case two which i will soon
show what is that case if delta q is equal to 0 delta u is minus delta w which tells me that if
system does some work then delta w is positive okay then delta u is negative
because this quantity is positive if this quantity is positive delta u is negative
which means the internal energy of the system must go down system is doing some work at the cost of
its internal energy on the other hand if i do some work on this system then delta w becomes negative
because of this negative sign delta u is positive that means i am doing some work on the system and

its internal energy goes up
so this is consistent with whatever we have discussed
so far this
is the first law of thermodynamics and then i briefly mentioned what is an internal energy
ok internal energy if i consider ideal gas internal energy is proportional to temperature ok
these i have not proved but for an ideal gas its function of temperature proportional to
temperature if i increase temperature internal energy goes up this constant has no relevance
kinetic theory has already taught us that average kinetic energy of the molecule is related to the
temperature
so internal energy if you consider mono atomic ideal gas molecules then this quantity
c v takes care of counting the degrees of freedom and we already know in kinetic theory average
kinetic energy is related to temperature
so if you talk about ideal gas molecules your internal
energy is simply translational if it is monoatomic it is translational vibrational and rotational
if it is diatomic or polyotamine ok
so it is the internal energy means the energy i was talking
about in kinetic theory if i consider ideal gas molecules who takes into care the fact that
it could be mono atomic it could be polyatomic that is in cv we calculated cv elaborately using
equipartition and that equi partition tells us that whether the molecule is mono atomic diatomic
or poly atomic goes into calculating the number of degrees of freedom and that is reflected
in the specific heat capacity
so this is the internal energy and second quantity is it is
extensive that means if you double the size double the number of molecules definitely it
will get doubled
so it is an extensive quantity as i said in the beginning
so internal energy is
extensive quantity secondly i want to bring a very important notion here its a state function what
do we mean by state function state function means if i go from a state which is
characterized by p i v i and t i to a state p f v f t f by means of any thermodynamic
process ok i will define the thermodynamic processes for you in couple of minutes this
internal energy only depends upon the initial and final state thermodynamic variables it
depends upon the values of thermodynamic variables which is initial and final ok it does not depend
upon the thermodynamic process which is involved in taking the system from this state to
that state which is very very important

so it is a state function means it is determined
by the thermodynamic variables of a state ok for   example in ideal gas if you see its proportional
to temperature if i make a process in which   my temperature goes from t i to t f so
change in internal energy will be simply c v   t f minus t i it does not depend how i
have achieved this process in going from t   i to t f ok this is very important it is
a state function but q and w not
so heat   absorbed or work done by the system they are not
state functions they are functions of the process   ok
so as i have written here delta q delta w
and that is why this delta not d delta q delta   w depends on the path thermodynamic process ok
soon will explicitly calculate them and show   that they indeed depend on the thermodynamic
process d u doesnt ok it only depends on the   initial and final set as i have calculated here
so this is a very important notion and there is a   connection between mechanics okay we have
already seen adiabatic process this is how   thermodynamics brings in the concept of state
function or internal energy if you have an   adiabatic process ok
so in an adiabatic
process you know delta q is equal to zero
so there is a work done by the system or i
am doing some work on the system if i say   that there is no friction there is no dissipation
what do i have i have a work which is conservative which is conservative this is very very important
so i am doing a work which is conservative and now   let us recall our mechanics course in mechanics
we already know in a conservative force field   work done does not depend upon the path i take
for example if particle in a gravitational field   was initially here i take it here i can take
it in many possible ways as many ways you like   someone can take it just vertically upward ok
but the work done in all the processes are same   does not depend on the path rather it depends upon
the difference of one quantity in the final state   and the initial state that quantity i called
potential in our mechanics course ok
so potential   work done in a conservative force field is in a
conservative force field work done is just the   difference in potential difference in potential
please note that what i am referring as potential   is nothing but the
so called potential energy
or rather i am using the term potential   to denote potential energy it does not depend on
the path and if i do a work in a closed loop in   a conservative force field i start from here
and i come back to this point net work done   is zero because i come back to

this same position
potential is the same
so change in potential is   zero that is why my work done will be always be equal to zero
so this is from mechanics   and you see in an adiabatic process work done is path independent it does not depend on the   path because it is a conservative force field
and that gives in the idea of internal energy
so if you remember if you understand how do we get
the concept of potential in classical mechanics   you immediately get what is internal energy
in thermodynamics ok
so it is a state function   ideal gas as i have mentioned already d u
depends on initial and final temperature   because it is a function of temperature only
so if you understand what is the conservative   force field and how do we get the concept
of potential in a conservative force field   you immediately get to realize what is
internal energy in a thermodynamic process   ok and for an adiabatic process it is clearly
a state function if you consider ideal gas   because i told you in an ideal gas
its just cvt plus some constant   this constant has no relevance in essence we are
interested in the difference of internal energy   as in mechanics we are interested in the
difference in potential
so this is the   first law of thermodynamics for us this is the
meaning of internal energy i talked about two   extreme processes one is completely adiabatic
only mechanical work is being done other is   process which is diathermic in which i allow
heat exchange but general process involve both   one is heat exchange other is
the mechanical work   ok now this is the question since i
have been talking about work
so much   what is the work done by a gash well i will always
assume quasi static process that means at any step   at any instant of time i can use my ideal gas
equation i will always be considering ideal gas   not van der waal gas at any point on time so
far if not otherwise mentioned its ideal gas   could be one mole could be n mole but i will
always assume quasi static process
so that at   any instant i can use the equation p v is equal to
n r t
so what is the work done let us assume that   there is a container there is some pressure some
p and there is a small shift d x this is the area   of the cross section and there
is a pressure p let us say ok   now what is the work done work done i know
force into displacement
so i am just looking   at the magnitude of the work done
so work done
should be force which is pressure times area   which is dimensionally consistent

and d x is
this displacement of the wall of the container let us say for example for simplicity we are
taking a rectangular wall okay
so it is displaced by an amount dx this is the work done which i can write as pdv
so i have expressed everything in terms of pressure and volume one intensive and
one extensive thermodynamic variable
so what will be the network done network done is integral p d v from v one to v two
so i am assuming that initially i was as a volume v one then the volume of the system increases or decreases to v two ok i am doing this change quasistatically
so this
is the work done now if i recall my pv diagram this is pv diagram let us say
so what
does it imply i am integrating p d v this is my initial volume v one this is my
final volume v two and this is the work done
so work done it is simply the area under the curve
in this pv diagram ok
so we have to calculate this area under the curve for
different thermodynamic processes
so this is our next time and this will take
some time and we will try to understand the physical meaning of every process
so we will
do it for different thermodynamic processes ok so let us consider for simplest thing isothermal
process what do you mean by an isothermal process temperature is fixed t fixed immediately
you already know one thing if temperature fixed i am talking about ideal gas d u is equal to
zero there is no change in internal energy because in ideal gas internal energy is
just the translational kinetic energy if i consider mono atomic ideal gas molecules
its just translational and its proportional to temperature is temperature is kept fixed d u
must be equal to zero now you want to calculate this quantity and you know since its a quasi
static process every instant in time you can write p v is equal to n r t
so that you can write
this integral as i have written here clearly as n r t v 1 v 2 d v by v ok all i have done i
have substituted for p v here p v is equal to n r t which gives me p is equal to n r t over
v ok if i substitute it back in this equation i simply get this form and now i can integrate
from v 1 to v 2 this gives me this expression
so in an isothermal process this is the work
done there is no change in internal energy so whatever heat is supplied to the gas will be
converted to work done if i give delta q amount of it system will do this much

of work because there
is no change in internal energy
so entire heat supplied whatever i have supplied to the ideal
gas system will go into work done by the system
so this is an isothermal process
important is d u is always zero i am considering ideal gas molecules ok
quickly i will go to the next process isobaric again what does it mean
isobaric means pressure is constant pressure is constant which means i will go
from a state p v i t i to a state p v f t f ok its my ideal gas system ok
initial pressure and
final pressure is the same there will be a change in temperature and volume
that is what i need to
calculate and this expression will be different and d u internal energy change
in internal
energy is there in this process i cannot say d u is equal to zero rather d u
not equal to zero
in this process
so in an isobaric process d u is not equal to zero remind you all the time
that this delta q and delta w depend on path that means they depend on the
thermodynamic processes
i will always write d u to remind you again that u is path independent depends
on the initial
and final state value of u depends on either initial state or final state d u
depends on the
difference in initial and final step difference in thermodynamic variables
so isobaric process
pressure is constant we can do this integration very easily ok take the
pressure out of the
integral its a constant
so its p v two minus v one its simply p times v two minus v one and since
i am talking about ideal gas in both the cases its p v one is equal to n r t 1
in the initial
state p v 2 is equal to n r t 2 in the final case
so it is simply given by the difference
in temperature
so i have kept pressure constant ok volume and temperature both of these
quantities
change
so p constant v and t change and this is my net work done i can write it
expressing entirely
in terms of change in volume or change in temperature because i am using ideal
gas and i
am doing a quasi static process if i do not do any quasi static process i do a
rapid change i
can go from one state to the other very rapidly but i have to wait initially
it was in
equilibrium with p v one t one finally it may reach an equilibrium which is p
v two t
two but i cannot say work done is this because i did not do a quasi static
process rather i
did a rapid change and finally i have to wait for the system to equilibrate ok
this is
another process
so two thermodynamic processes we have already learned one is isothermal

process and second one is isobaric process   lets go to the third one isochoric process
so volume is kept constant i am not allowing   volume of the container to change immediately
i know that i am not allowing any work no work   as i have written here no work is done
neither i am doing any work on the system   nor the system is doing any work on the rest
of the universe
so volume is kept constant
so work done must be equal to zero it is
p d v ok work done i again remind you i   told you integral p d v this d v is zero
if d v is equal to zero no net work done   ok
so the heat supplied to the gas is converted to
internal energy that is the first example i said   that i am supplying some heat ok if you
remember this represents this situation   i was talking about that this situation where i
said that delta q this or this whichever notation   you prefer is the amount of heat supplied to
the system but there is no mechanical work ok   which means there should be an increase in
internal energy which i am showing here that there   is an increase in internal energy recall the first
law recall the first law i was not saying delta   q and delta w are conserved ok i am saying take
delta q delta w and d u if you like all together   and then you can have conservation of the total
energy that is my first law of thermodynamics   this is why internal energy is essential internal
energy is essential to consume the total energy   heat absorbed increases the temperature and hence
the internal energy remind you that i am talking   about ideal gas systems internal energy is
directly proportional to the temperature   if i supply some heat to the system it increases
the temperature and hence there is an increase in   the internal energy these three examples
also establish that work done by the gas   depends on the thermodynamic processes
so amount
of work i am doing depends upon the process   that is why this notation delta w ok depends
on the path path means whichever process i take   the process could include
or process could consist of   two or many thermodynamic processes may be first
half is isobaric second one is isothermal we will   see this type of multiple processes when i talk
about heat engines or obvious
so ok when i talk   about heat engine or refrigerators these things
will be clear it could be for example isobaric plus isothermal ok multiple processes in going
from one thermodynamic state to the other   ok this is an example ok and the work

done will entirely depend on the process i have employed what is important change in internal
energy will be the same if i start from the same initial state always and reach the same final
state always it just depends upon the initial and final state in precisely speaking depends upon
the difference in temperature since i am talking about ideal gas throughout ok now comes the final
one what is the work done in an adiabatic process adiabatic process is complicated here delta q is
equal to 0 that's important delta q is equal to 0 that means delta u must be equal to minus of
delta w this is very important w depends on path ok but d u doesnt
so if i have an adiabatic
process then w will be path independent thats what i was trying to say in mechanics
conservative force field work done is path independent brought in the concept of potential
potential energy if you like similarly here w is path independent which gives the concept of
internal energy ok this is my delta w which is p delta v which i have defined now let us
recall in kinetic theory we defined cv and c p ok ok we used equi partition theorem counted
the number of degrees of freedom and then we could easily find out what is
the number of degrees of freedom contributing to the specific heat and i used c p
minus c v is equal to r for one mole of ideal gas and i said i will not provide any proof at that
point now is the time we can look at it more critically
so isochoric process which means
volume is constant remember no work done volume is constant if volume is constant
i can define c v that is what calorimetry teaches us that delta q is the amount of
heat let us say supplied to the system and delta t is corresponding change in temperature
so delta q by delta t keeping v constant this notation means i am keeping v constant let me
go this way
so this keeps v constant this is d u d t keeping v constant similarly if you
consider a process which is isobaric process in an isobaric process you keep
pressure constant ok pressure constant
so this is
delta q heat supplied to the system delta t increase in temperature
but pressure is kept constant c p this is d u d t ok what is delta q delta q
already we know from first law as i have written there delta u plus delta w which is nothing but
delta u plus p delta of v i am writing delta here and consistent notation same notation for q u
and w but never forget these two depend on path whereas delta u does not
so if i use this pressure
is kept constant i want to take this derivative pressure constant and limit d t
tending to zero what i find out since pressure is constant first

piece will come from internal energy and then pressure is coming out its a
constant
its an isobaric process
so delta v delta t holding pressure constant
so this is my cv this is my
cp and i want to know what is the difference between cp and cv this is
important because
what is our purpose we want to calculate pdv in an adiabatic process in an
adiabatic process
temperature will not remain constant temperature changes it is not an
isothermal process if
temperature changes we immediately know there will be a change in internal
energy also
so change in
internal energy because of change in temperature and i cannot either use p v
is equal to constant
i cannot say it is not an isothermal process we know p v is equal to r t for
an ideal gas one mole
of ideal gas if temperature is constant then i can say pv is equal to constant
ok but it is not an
isothermal process
so temperature is not constant ok
so i cannot say p v is equal to constant we
have to be careful firstly purpose is to calculate in an adiabatic process t is
not constant we cannot use p v is equal to constant which is r t rather for an
adiabatic process i
must have some other equation some other relation relation which is very
important
which i am going to derive for you this relation is p v gamma is equal
to constant need not be the same constant as the previous one a different
constant ok which i will derive for you now for an ideal gas since we are
dealing
with ideal gas we are lucky ok we are lucky for an ideal gas u is a function of
temperature
only
so this derivative if i write in derivative form its d u d t keeping volume
constant but this
fellow is a function of temperature only similarly this is d u d t keeping
pressure constant ok so
these two derivatives since i am assuming internal energy as a function of
temperature only
so these
two carry no sense ok since internal energy is a function of temperature only
these two are same
now look at this equation what you have cp what is this quantity you are
calculating p delta v delta
t and you can immediately arrive at the equation this is your cp this is your
cv all you are left
with c p minus c v is equal to p del v del t p and if you calculate it for one
mole
of ideal gas for which you already know pv is equal to rt pv is equal to rt if
you
calculate this quantity this immediately gives you cp minus c v is equal to r
this is a

very simple but very insightful proof of this relation that for one mole of ideal
gas cp minus cv is always equal to r that can be proved i have shown in a very simplistic
way i repeat the proof c v is change in internal energy when you change temperature by
f amount delta t keeping v constant cp on the other hand has p constant
so it will
have a piece this and this space this this is the extra piece now i am arguing that for an
ideal gas ok i should always have this quantity equal to this quantity this p and v which i have
written here they do not carry a sense because for an ideal gas u is a function of temperature
only if that be the case this first term cp minus cv if you do this term cancels with
this term all you are left to it with this term and if you calculate using pv is equal to
rt here you simply get cp minus cv is equal to r
so first thing i have proved for you with some
basic arguments say cp minus cv is equal to r now i have to establish this for you i have not
defined what is gamma for you
so i have to define what is gamma ok and arrive at this relation
so lets proceed
so purpose is to know what is constant for an adiabatic process as we know in
an isothermal process pv is constant
so let us proceed
so delta q is zero because i am talking
about an adiabatic process d u is this quantity which can be easily found out ok this p delta v
now d u i am talking about one mole of ideal gas
so d u is equal to c v d t that is what i have
replaced here you can easily see remember cv t plus constant that is what i wrote
as the expression from internal energy this constant never matters its never relevant
because i will always talk in terms of difference in internal energy
so this is important
any thermodynamic extensive variables like internal energy free energy etc we can always add
a constant to that you know in classical mechanics results do not change on where you set the zero
of your potential energy
so cv dt is minus p d v this is simply from this equation once you
said delta q is equal to zero it follows from the first law
so i can write in differential
form now c v d t is equal to minus r t delta v by v what i have done i have substituted p is
equal to r t by v let me write probably here p is equal to r t by v okay
so i have
cv dt p dv substituted for p r t over v and already in the previous slide we have proved

for ourselves that c p minus c v is equal to r
so c p minus c v is equal to r and you get an
expression like this i write it here again
so c v d t is equal to minus c p minus c v by v times t
and let us write also delta v in differential form to be consistent okay
so this is the equation c v
d t is equal to minus c p minus c v over v times t into d v ok everything is
in differential form
now and now i can finally arrive at this equation now i have intentionally
not
written where is gamma here you can immediately see gamma is nothing but
cp by cv
so ratio of specific heat capacity at a constant pressure to the specific
heat
capacity at a constant volume that is your gamma that is cp by cv well
so this is the equation
you have now i write it again for clarity dt by t is equal to one minus gamma
d v by v now
you can integrate if you integrate you get this result its very simple
integration you always
know d t by t if you integrate you get a log t ok thats what precisely i have
written here log t
one minus gamma log v plus some constant which comes from integration and
so that gives me t is
proportional to v to the power one minus gamma
so i have a relation in an adiabatic process ok
i can put it in more succinct form if i proceed i had this relationship which
was telling me t is
proportional to v to the power one minus gamma t is proportional to v to the
power one minus gamma
or i can write t is equal to some constant time v to the power one minus gamma
now use p v is equal
to r t because i am using one mole of ideal gas one mole of ideal gas i use p v
is equal to r t
this relation is p v gamma is equal to constant ok the question i asked
question i started with for an isothermal process
you have pv gamma is constant it is a quasi static process at every instant
of time its in equilibrium and its your p v is equal to constant this is
your isothermal process what is the corresponding relation in an adiabatic
process
remember adiabatic process is also quasi static but temperature is not constant
rather you will
have p v gamma is equal to constant ok for an adiabatic process p v gamma is
equal to constant
that is what we have to use when we want to do this work done in an adiabatic
process
ok remember this constant if i called c isothermal this constant is c adiabatic
ok
maybe i can write this in the following way that in an isothermal process p i
v i
it does not refer to initial state rather it refers to a process ok maybe
to be precise i use capital ok
so p i v i that means isothermal process is
a constant ci for an adiabatic process adiabatic process on the other hand you

have
p a v a gamma some other constant c a ok the subscripts here refer to the
process not the initial value   now if i give you two isotherms or two pv
diagrams
not isotherms i correct myself adiabatic process   temperature is not constant
 so i give
you two curves two pv diagrams and   ask you the question if one is adiabatic
and
other is isothermal which one is isothermal   which one is adiabatic i leave
this question
with you and in the beginning of the next lecture   we will come to that that
given two curves in
the p v diagram on the p v plane ok i am telling   you one is isothermal and one
is adiabatic you
have to tell me which one is adiabatic and which   one is isothermal but by
looking at the curves or
rather looking at the slope of the curves this is   a hint
 so our initial purpose was to calculate the
work done in an adiabatic process and adiabatic   process is complicated you are
going from p one v
one t one to p two v two t two ok earlier remember   earlier we were keeping one
of them fixed
in isothermal process i was having t fixed   isochoric process i was having v
fixed ok in
isobaric process i kept p fixed but when i have an   adiabatic process all the
thermodynamic variables
change but there is an important simplification   p one v one gamma should be
equal to p two v
two gamma that is what i have proved for you   well now what is the work done i
have to
calculate w v one to v two and then p d v which now i can write since
this is always satisfied   it is a quasi static process every instant this is
satisfied i can write it as c adiabatic and then d v by v to the power gamma v
one to v two ok now
all you have to do you have to do this integral   and if you do this integral
you will find out   work done i am not doing the integral for you
you can very easily do that one minus gamma p two v two minus p one v one this
is the
work done in an adiabatic process automatic   process is very complicated
because all the
thermodynamics variable change but keeping   this constant and that enables us
to find out a
closed form expression for the work done ok and   this is the expression for the
work done and now
pv is equal to rt is always satisfied after all   it is ideal gas
 so it is satisfied initially
also in finally ok
 so you can write this as r t one minus t two by gamma minus one ok this is the
final answer and gamma is always
greater than one because c p exceeds cv
 so this   is the work done in an adiabatic process and i
will come back to this in the next lecture and   what is the essence of today's
lecture
i talked about work done by the gash   and established for you that it depends

upon
the thermodynamic processes ok whichever process you take it depends on the thermodynamic processes
for example it is 0 in an isochoric process most complicated is the adiabatic process i have given you an expression in the next lecture we will start again from
the adiabatic process thank you for today you