hello students welcome to lecture
four of chemical equilibrium i will start with recap which i did
in the last lecture that is your in the last lecture i discussed
about leachate earlier principle   the most important use of le chatelier's
principle is we can know under what condition   a reaction can give maximum
product a reaction
can give maximum yield what do i mean by condition   we can change concentration
we can change pressure
we can change volume and we can change temperature
 so if we understand leachate earlier principle you
will be able to tell if i increase the temperature   whether reaction will go to
right hand side means
more product will form or less product will be   formed similarly if i increase
the pressure
and what will happen to the reaction whether   reaction will shift towards
forward direction
or reaction will shift towards reverse direction what leachate earlier principle
tells you it tells
you that if we alter the conditions for example   pressure temperature of volume
we can disturb
the equilibrium we can disturb the equilibrium   finally a new equilibrium will
be established this
principle tells you that new equilibrium will be   in which direction whether
equilibrium will
shift to right hand side or left hand side   the law tells you that equilibrium
will shift to
that direction which tends to minimize the change   equilibrium will shift to
that direction
which tends to minimize the change then we looked at the effect of increase in
pressure
 so suppose i am increasing the pressure   that can be done by decreasing the
volume ok   i showed you that in that case delta
if delta n is positive reaction will   move towards reverse direction or
reverse
reaction will be favored what i mean by delta n is   your change in strike you
matri
 so basically it is
the stoichiometry of product minus stoichiometry   of reactant if this is
positive then reverse
reaction will be favored if it is negative   then forward reaction will be
favored when we
increase the pressure
 so this is about when i   increase the pressure
 so if reaction has delta n
is positive increase in pressure will favor the   reverse reaction whereas if
delta n is negative
increase in pressure will favor forward reaction pressure can be changed in
another way
pressure can be changed can be changed by introducing introducing your inert gas
inert gas
 so first condition we discuss that when we
change pressure by decreasing the volume   or increasing the volume pressure
will be
increased if we decrease the volume whereas   pressure will decrease when we

increase
the volume but we can increase the volume we can increase the pressure by introducing
inert gas keeping volume constant so suppose i am taking a closed container closed
container and then we have molecules of a and b is your reactant b is product i can
increase the pressure by introducing another gas which does not interact with a or b which
does not interact with a and b and that is basically you are introducing inert gas overall pressure is increased volume has
not increased ok in that case what happens
so i discuss this reaction p c l five gas
giving you p c l three gas plus cl2 gas cl2 gas in this case kp can be
written as pressure of pcl 3 into pressure of c l two divided
by pressure of p c l five and pressure is your mole fraction of p c l three
multiplied by total pressure into mole fraction of c l two multiplied by total pressure divided by
mole fraction of p c l five into total pressure and then this can be written and mole fraction
can be written as n of p c l three divided by n t where n t is total amount of gas total number of
gaseous molecule this not only includes reactant and product but also includes inert gas
so n t
multiplied by n c l two divided by n t into p this is also into p ok divided by again n p c l
five by n t into p one p one p cancels out one n t one n t cancels out
so what we are
left with n p c l three into n c l two divided by n p c l five ok and then one pressure left
this side pressure by n t
so now you see you have this quantity and k p your the direction will depend on
whether p by n t is increasing or decreasing if it increases then what will happen this
value will decrease to keep k p constant while if this decreases this will increase
to keep k p constant
so what happens you see p by n t i told you that reaction
was carried out in closed container what does that mean is you have a constant volume
condition under constant volume and temperature
so p by n t is constant p by n t is constant
and
so basically this does not changes and so there is no need for change in this quantity
what does that mean is that introduction of inert gas will not have an effect on a reaction
if reaction is if pressure is increased by addition of inert gas at constant volume
so in a closed container in a closed container container which means constant volume system introduction of introduction
of inert gas inert gas does not have effect on the reaction even if there is

there is increase in
increase in pressure increase in pressure but suppose if i carry out reaction
which has a cylinder which is like piston
ok and then you have reactant you have product and now what you did is you
increase the volume increase the volume such that if i
introduce inert gas if i introduce inert gas   the pressure is constant total
pressure
is constant total pressure constant   but volume changes a volume increased
volume changes ok
 so this volume is   greater than
 so this is v two if suppose volume
is this this is v one v two is greater than v one and introduction of inert gas
does
not introduction of inert gas does not   increase the pressure pressure is kept
constant in that case what will happen
 so lets again discuss this reaction p c l five
gas going to p c l three gas plus c l two gas ok
 so k p is equal to your again pressure of p c l   three multiplied by pressure
of c
l two the pressure of issue five and this is mole fraction means n of p c l
three by n t multiplied by total pressure   into n c l two by n t into total
pressure
divided by n p c l five by n t into s   one pressure one pressure cancels out n
t one
n t n t cancels out
 so this is basically this   n p c l three into n c l two divided by n
p c l five and multiplied by your p by n t now you see this p is constant and
your nt
change and t increased because you introduce the   you introduce the inert gas
if you introduce the inert gas   and int changing since nt is in denominator
basically increase in n t means p by n t is   decreasing p by n t decreased so
this must increase to compensate for   your k p to keep k p constant this value
should
increase since p by n t is smaller p by n t   is smaller when that will increase
this will only
increase when your npcl3 are npcl3 and ncl2 will   increase it means reaction
goes towards forward
direction reaction goes towards forward direction
 so if n t is delta n is where delta n is your
your difference between your stoichiometry of   product minus trichometry of
reactant if this is
positive as in case of your p c l five going to   p c l three plus c l two your
introduction of introduction
of inert gas inert gas at constant pressure at constant pressure will will shift
the reaction to reaction to
forward direction forward direction to forward direction
 so this is about
effect of inert gas inert gas will change   the pressure inert gas may not
change the
pressure
 so the shifting reaction will depend on   under what condition you are
carrying
out the reaction ok
 so now pressure   volume is done what will do is will go

to temperature effect of temperature effect of temperature on equilibrium effect of temperature on equilibrium

so effect of temperature will depend on whether reaction is effect of temperature will
depend on whether reaction is reaction is   exothermic exothermic or endothermic endothermic if reaction is your exothermic if reaction is is exothermic exothermic

so basically delta h is your negative what does this mean exothermic
means a plus b giving you c plus d   and heat is released plus heat released in this case if i increase the temperature if we
increase the temperature increase the temperature temperature reaction will shift towards that side the reaction will shift will shift to the direction where heat is absorbed where heat is absorbed absorb since in exothermic heat is released so
heat is absorbed for a reverse reaction

so if i increase the temperature if i increase
the temperature the reaction well shifts towards   your reverse direction the reaction
will shift towards reverse direction

so basically exothermic reaction
exothermic reactions exothermic reactions are favored at low temperature if i go to if i take reaction which endothermic ok endothermic endothermic it means your heat is absorbed it is absorbed delta h is your greater than zero so it is positive in this case   if i increase the temperature
if we increase the temperature the temperature if we increase the temperature forward reaction will be fewer favor since in the forward reaction heat is absorbed   in the forward reaction heat is absorbed favored now lets understand what happens to k p to k p with temperature with temperature before that we told that k p does not
change with number of moles of pressure pressure or volume but k p depends on temperature

k p depends on temperature k p depends on temperature the equation which governs the effect of the effect of your temperature the equation which govern effect of temperature on k p or k c is given by del log k   p by del t at constant pressure is equal to
delta s naught by r t square r t a square   ok

so k p will depend on the temperature dependence of k p will
depend on delta h naught

so if i take   endothermic reaction endothermic reaction reaction your k p increases with increase in
temperature increase in temperature while k p for exothermic reaction exothermic reaction k p decreases with increase in temperature k p decreases means your product well will decrease and reactant will increase increase and that means is that reverse reaction reaction is favored reverse reaction is failure

so in summary your exothermic reaction exothermic reactions are favored at low temperatures low temperature whereas endothermic
endothermic reactions are reactions are favored at favored at high temperature now lets take some example and see   what happens when we increase the temperature

so effect of temperature

so first reaction is your so2 gas plus
o two gas giving you s o three gas

so when s o two reacts with o two to give s

o three your heat is released it is released and it is an exothermic reaction and delta
h is equal to minus eighty kilo joule delta h is equal to minus one
eighty kilo joule per mole since this is a exothermic reaction
if i want to increase the product   what should we do we should go to low temperature
it should decrease the temperature because   exothermic reactions are favored by
exothermic reactions are favored by your are favored at low temperature
low temperature
 so if we want   higher yield of so3 higher yield of
so3 we should decrease the temperature   now let us take dissociation of n two o four the
second reaction is dissociation of dissociation of n two o four
 so n two o four gas dissociating two two n o two gas two n o two gas   ok n 2 o 4 dissociating to n o 2 gas in this case
your reaction is basically endothermic it means   that heat is absorbed during the process heat is
absorbed during the process delta h is positive
 so if we want more dissociation if we want more
dissociation we have to increase the temperature   we have to increase the temperature
because endothermic reactions are endothermic reactions are endothermic
reactions are your favored at endothermic reactions are
favored at high temperature can think of about several different cases
for example methanol production c o gas   plus two s two gas giving you c h
three o h gas   and delta h naught is equal to delta
h is equal to minus 270 kilo joule per kilo joule per mole now again you see
this   to know the effect of to know the effect of
temperature on a reaction we must know whether   it is the reaction is happening with
release of heat or absorption of it   in this case heat is released and
so this reaction will be favored act low temperature low temperature means if
we decrease the temperature   we are we can expect to get higher amount
of methanol higher amount of methanol now we can use it in oppositions also
 so suppose
a reaction a plus b going to c plus d lets   take this in gases form ok if we know that with
increase in temperature increase in temperature product is increasing product is increasing that will give you clue
about whether heat is absorbed or released in   a reaction since product is favored when
i increase the temperature it means that   heat must have been absorbed in the system ah
absorbed during the reaction what does that mean   is that your reaction is endothermic
reaction
 so reaction is endothermic reaction is endothermic on the other hand i get with increase
in temperature increase in temperature   the amount of product decreased
decreased then we can simply say that your reaction
is exotherm reaction is exothermic reaction is exothermic
 so just by
looking at reactant and product how much they increased when we increase the

temperature we can tell whether a reaction is   endothermic or exothermic heat is absorbed
or released
 so we just saw the effect of   concentration pressure inert gas and temperature
on the equilibria now we know what will happen   if i increase the temperature if i increase
the pressure if i introduce the inert gas   and we can know in which direction reaction will shift   and that can be applied if i want to increase the product if we want to increase the   product
 so this information will help you
whenever you are trying to carry out a synthesis
 so let us go and see some more examples some
more examples for example let us take this case   s two plus i two s two gas plus
i 2 gas giving you 2 h i guess which i guess now suppose i want
to know the effect of your pressure   effect of pressure effect of pressure effect of pressure
 so must remember that
last time i did showed you what will happen   when we alter the condition
 so see this just
want to show you that we discussed what will   be the effect of increase in pressure if delta
n is positive reverse reaction will favored   with increase in pressure whereas if delta n is
negative then forward reaction will be favored   with increase in pressure now lets see
what is delta n here
 so delta n is your you see this case two moles of h i so
two this is the product minus reactant   reactant is what one plus one
 so this is zero this is zero
 so what does that mean is pressure   will not affect pressure
will not affect the reaction if suppose we increase the volume to double
pressure will decrease but since del n is zero
so even the effect there will no no no effect   of increasing or decreasing the
volume no effect of inert gas either even at constant pressure since del n is zero
only thing which can affect this reaction is   temperature
 so if it is an endothermic reaction
the effect of temperature will be different   and if it is exothermic effect of temperature
will be different now lets take another example four ns3 gas plus five o2 gas giving you
four and no gas plus six s two gas   six is two gas
 so lets see whether it is balanced
or not four nitrogen four nitrogen twelve hydrogen   12 hydrogen 10 oxygen 4 oxygen plus 6 oxygen
or 10 oxygen
 so this is your balance equation   and we want to see the effect of pressure volume
anode gas or temperature
 so let us see delta n   first we have to calculate delta n ah delta n
is your stoichiometry of product
 so four plus   six ten minus four plus five nine is equal to

one
 so it is positive it is greater than zero   it means there will be effect of pressure
there will be effect of pressure here delta n   is your delta n is positive and that means that if
i increase the pressure if i increase the pressure reverse reaction will be favored reverse reaction will be favored if i
increase the volume pressure will decrease pressure will decrease and your forward reaction will be favored
 so if i increase the pressure reverse reaction
will be favored if i increase the volume your   forward reaction will be favored effect
of inert gas if i keep volume constant   if you are doing that in a closed
container then there will be no effect   but if we take the case of constant pressure
i introduced inert gas such that pressure is   constant in that case your forward reaction
will be favored forward reaction will be now suppose take s two plus c l two
gas   this is your s c l two s c l plus ninety
two kilo joule ninety two kilo joule if suppose this is given ok now lets think of
what is effect of pressure temperature and volume   what is effect of pressure temperature on board
now you see this that your 92 kilo joule of heat   is released
 so this is your exothermic reaction
this is your exothermic reaction in that case temperature will have effect whatever pressure and volume   for pressure
 so looking for ah looking at
effect of pressure of volume at equilibrium   we must calculate delta n and delta n is
your two minus one plus one which is zero   what does that mean is increase or decrease
in pressure will not affect this reaction   not affect this reaction all are in gaseous phase
all are in gases phase ok but introduction of   again introduction of inert gas will also not
affect this reaction whether it is carried out   at constant volume or constant pressure only
thing which is going to affect this reaction   is your temperature and since this is a exothermic
reaction since this is a exothermic reaction   your temperature increase in temperature will not
favor the reaction basically a low temperature   will favor the reaction low temperature will
favor the reaction now take another case s two   gas plus i two gas giving you two h i two
h i gas and delta h is equal to twenty five   kilo joule this is plus kilo joule what does
that mean is the reaction is your endothelial reaction is endothermic
 so suppose if we
are trying to look at effect of pressure pressure or volume first we calculated
delta n and delta n here is two minus   one of s two and one of i two and
 so this is
zero

so no effect of pressure volume no effect of pressure or volume what about others no effect of inert gas inert gas whatever temperature temperature will affect

because this is an endothermic reaction and endothermic reaction are favored at high temperature

so high temperature high temperature will increase the product which is h i in this

case which is h i in this case another reaction two n o two gas giving you n two o four n two o four

and this is your delta h is negative what does that mean this is exothermic reaction

now we can see that this is also in gaseous form what is delta n delta n is one

minus two which is minus one it means pressure volume will affect if i increase

the pressure first thing increase the pressure what will happen if i increase the

pressure of you see this is the minus one ok

so forward reaction will be favored favor if i increase the volume reverse reaction will be

further reverse reaction will be if i increase the temperature now you see this is exothermic reaction

and in exothermic reaction you do not exothermic reactions are not favored at high

temperature they are favored at low temperature so reverse reaction in this case

will happen will be favored another way to remember is that

increasing the temperature will shift the reaction toward that side in which heat is

absorbed

so if i take the reverse reaction in this case your delta h will be positive or heat will

be absorbed

so dissociation of n two o four is an endothermic reaction and

so with increase

in temperature reverse reaction this is this dissociation will be favored ok inert gas effect

of inert gas at constant volume it will not affect but at constant pressure

your reaction will be reaction can be affected reaction can be affected it will just opposite to this in this

case your reverse reaction will be favored now last is the effect of your catalyst effect of effect of catalyst what

will happen

so effect of catalyst catalyst on the equilibrium equilibrium ok

so what happens

when i you add the catalyst know this is the potential energy

or energy versus reaction coordinate ok this is kind of safe we get this is your reactant this is your product and this is transition state this is the transitions

so if we have a reaction and if we do add catalyst what can happen we know that

if i add a catalyst

so in presence of catalyst this curve will be something like this what does that mean reactant and this is product

and this is transition state
 so catalyst basically stabilizes the transition
stereo
 so it went down from this point to this
 so reaction activation energy decreased activation
energy decrease
 so reaction will be faster   but does it affect equilibria ok question
is does it affect equilibrium catalyst does not affect equilibrium as an
effective equilibrium because you see what is your k k is your k f by k b k f is
your rate constant for forward direction
and k b o is rate constant for backward direction   k f k b changes when we add
a catalyst but
the ratio does not change ok
 so k f changes k changes because activation energy   will be lowered and if
activation energy
for forward reaction is lowered it means   kf will increase but catalyst also
decreases
activation energy of reverse reaction of the reverse reaction and so
kf also increases
 so k f changes   there is increase in k b increase in k b and
increase in k f but the ratio remains constant k   f by k b remains constant and
that means that
there is no effect of catalyst on the equilibrium you can understand this from
here
so what happens that you have energy versus reaction coordinates or extent of
reaction you have this kind of curve and there is no
catalyst and this is activation energy for   forward reaction this is
activation
energy of reverse reaction reverse reaction or backward reaction when
i add a catalyst what i get is basically
 so it is initially suppose this way it goes down the presence of catalyst
 so initially
you have this is eaf activation energy   of forward but in presence of catalyst
it decrease to this
 so this is e a dash f but you see activation energy of
reverse reaction also decreased   activation energy of reverse reaction also
decreased
 so it was here first
 so this is suppose   e a for a reverse reaction and now in presence
of catalyst this is decreased to this value   and when this decrease to this
value you
have a new e a r which is called e a dash r ok
 so your equilibrium constant is this is k f by k b k gets affected in presence
of catalyst   and it becomes k f dash and k b also changes
and that becomes k b dash but the value of k f   by k b and k f dash by k b will
remain same
so catalyst increases the rate of reaction   it increases rate of both reaction
forward
and reverse direction or reverse reaction but   the ratio of k f and k b does
not change
so ratio of k f and k b does not change and
 so catalyst catalyst catalyst does not affect the equilibrium does not affect
the equilibrium
 so in a nutshell we can change the direction of we can control a reaction by

changing changing conditions by changing conditions we can maximize the product maximize the product if maximize the product if we have understanding of understanding of lee chatelier's principle and that is why le chatelier's principle is very important   when we are dealing with a chemical reaction thank you very much you