

welcome back to the class of electrochemistry
so in the last lecture we started with galvanic cell and we learned how to represent
the half cells and maybe one or two example we have given and will continue with that now
ah as far as the cell potential or cell emf is concerned i already discussed how to uh you
know measure the cell potential it is basically by means of a compensation method which is
called the puggendops compensation method that you should use a sale of standard cell of
known emf and then compare that with the your unknown cell with the help of you
know you know an arrangement which is known to be progendups compensation method
so it is basically you have an external battery and then you have one resistance and then you have one standard cell and you have another unknown cell x and
this is a standard cell and then you connect through a galvanometer by this or maybe
the same arrangement over here here
so whenever there is no deflection against maybe a certain certain point in this resistance it is basically a wear a long wire and then
you are connecting with one wire where this galvanometer is connected
so this is generally nichrome or similar wear
so when this one is you know having no deflection and this one is having no deflection then the corresponding lengths will be basically will be ah proportional to the
proportional to the the potential difference or emf of the cell and then taking the ratio you
can find out this cell potential now why this arrangement is made because emf is the reversible
cell potential
so if you is a common voltmeter
so it is going to i mean in order to have a deflection in the voltmeter you you need to supply certain amount of x
additional current so that will drop that will be drawn from the sail and reversibility of the cell
will be lost
so that
is why in order to have this reversibility in the cell reaction we need to use this this method
so therefore therefore anyway
so cell e cell is $\phi_{\text{right}} - \phi_{\text{left}}$ when we use the reduction potentials
so let us take you know one example ah for a given you know chemical reaction how can we represent the corresponding how can you represent the corresponding the
cell that is the corresponding galvanic cell
so let us take the example $\text{Cu(s)} + 2\text{e}^-$
 $\text{g} + \text{in solution phase}$ that gets you $\text{Cu}^{2+} + 2\text{e}^-$ plus plus twice a Ag(s)
so this is the oxidation process and

this is the reduction process okay
so redox these are the coupled
process

so we know that at cathode cathode which is generally written as the right
hand electrode

so reduction is taking place

so the reaction will be $2\text{Ag} + 2\text{e}^-$ electron that gets you 2Ag solid anode it is a left hand electrode it is
oxidation and

the reaction will be Cu solid that gets you Cu^{2+} plus plus twice electron okay
so corresponding

half cells will be represented like this like $\text{Ag} + \text{Ag}$ solid and here it
is you know $\text{Cu} \rightarrow \text{Cu}^{2+}$ plus ok

so therefore you couple these two and so
therefore you have to put this in the right hand side and put this in the left
hand side

so your representation for the cell will be $\text{Cu} \mid \text{Cu}^{2+}$ plus then double vertical
line because

this solution and the other solution ok

so this is your left hand electrode this is your
right hand electrode here you have oxidation here you have reduction okay

so therefore therefore this is typically
the the representation i mean this way you are representing this particular
chemical reaction

that this chemical reaction is going to if you want to have this have
this overall chemical change like this in a cell then you need to
construct the electrochemical cell like this now let us come to ah come to
daniel

cell with which we started our discussion

so daniel cell in that case the the
representation for daniel cell will be $\text{Zn} \mid \text{Zn}^{2+}$ concentration
may be maybe unity

or something else then CuSO_4 concentration may be one for simplicity
i am taking concentration to be unity

so this is the this is the representation
for this is the representation for the daniel cell for the earlier one the
earlier example

your your e cell will be here e cell will be will be equal to $\phi_{\text{right}} - \phi_{\text{left}}$ that is

equal to $\phi_{\text{Ag}} - \phi_{\text{Cu}}$ plus $\text{Ag} + \text{Ag}$ minus $\text{Cu} \rightarrow \text{Cu}^{2+}$ plus Cu

so it is in it is in conformity
with the with the upac convention okay

so for here it is you can you can represent
in the same way now next is the next is that we we have we have ah two half
cells like this one and

this one and these are appropriately connected like with the help of salt
bridge then the
system is ready to go for you know for this for getting some electricity out
of it

so but

next is ah how to find out the half cell this up cell or that half cell half
cell potential

ok

so in order to because we do not know what will be the potential we do not

know what

will be the potential but the point is using the Nernst equation compensation method we can find out the cell potential

so cell potential is basically potential difference between these two

so then in that case what will be the contribution from this one and what will be the contribution from this one if we would like to know then we

would need to we would need to you know compare its potential with respect to some

standard potential that is the potential of another half cell whose value is already known

okay or whose value is assumed to be something ok

so that's typically that's typically the goal ok

so therefore measurement measurement of half cell potential in that case we need to take the help

of help of a standard you know half cell which is called the standard hydrogen electrode or standard hydrogen half cell okay

so it is basically represented like

this Pt solid then H_2 gas at one bar $p = 1$ bar then H^+ plus that means acidic was it

is one molar maybe one molar HCl ok and at all the temperatures when this condition is maintained at all the temperatures this ϕ is assumed to be

equal to 0 at all t provided the this condition and this condition is maintained

so it

is a platinum solid now basically it is a platinum wire or platinum plate on which the

finely divided platinum particles are you know you know coated

so it is platinized platinum electrode

so the pictorially I can draw like this you have this

so you have platinum where

platinized platinum were and this is one molar HCl and hydrogen pure hydrogen gas is bubbled

over here ok is bubbled over here here

so that the solution is saturated with hydrogen

whatever height whatever may be the solubility of hydrogen it is saturated with hydrogen and and

this is called the standard hydrogen electrode at all the temperatures it is its ϕ value

that is the half cell potential is assumed to be zero and the half cell reaction ϕ goes as follows like H^+ plus plus electron that gets to half H_2 gas one bar ok

so this is the ϕ this is the reaction so

therefore what you have to do if you want to know the half cell potential for this then

couple this electrode with either this one or with this one that means you construct the cell

construct the complete cell where where one electrode one of the two electrodes will be this

standard hydrogen electrode and then find out the emf of the cell may be at at

say 298 kelvin
 and then then this emf will be exactly equal to the to the unknown half cell i
 mean emf will be
 the potential for the unknown unknown half cell ok
 so so briefly what is what is done you you couple
 this hydrogen electrode like this
 so i shall abbreviate it like s h e and then you have this
 double vertical line then the second half cell second half cell and then so
 this is think that this is anode that is put in the left hand
 side and this is maybe cathode it is the right hand electrode
 and this is left hand electrode ok
 so so the anode reaction goes like this h plus
 plus electron that gets you half h₂ gas one bar and the and the right hand
 reaction will
 be right hand electrode reaction will be the will be the reaction of the
 electrode whose
 you know half cell potential you would intend to find out ok
 so that means that means you will
 be able to find out the reduction potential reduction potential of the right
 hand half cell ok
 so so in this case the
 concentration of the electrolyte
 so concentration of the redox redox active substances may be or electrolyte
 associated with the electrode ah is said to be set at unity ok and then then the
 cell potential
 so if you
 keep this like this then the the cell potential or emf or cell emf is equal to
 the equal to
 the standard standard electrode potential potential electrode potential or
 the standard reduction potential or standard reduction potential of the half
 cell in question
 so therefore what you
 can write is basically $E_{\text{right}} - E_{\text{left}}$ that is your standard value is $E_{\text{right}} - E_{\text{left}}$
 right minus E_{left} okay now this one is equal to zero
 so therefore E_{right} is equal
 to E_{left}
 so this way this way you can find out with this
 so you can find out the
 standard reduction potential of the unknown i mean of the of the half cell
 whose you know
 this potential half cell potential is not known ok
 so therefore therefore suppose we do not know the for the
 say for the daniel cell we do not know the ah half cell potential
 for this upsells c u two plus what you have to do just couple this with
 standard hydrogen electrode
 so it will be s h e your constructed cell
 will be s h e then c u 2 plus 1 n then c u solid c u metal
 okay
 so more explicitly pt platinum solid it is the platinized platinum
 electrode then you pass hydrogen pure hydrogen gas at one bar pressure and say
 put
 so do do the reaction or do everything
 all the measurement at say to ninety eight kelvin ok
 so twenty five degree centigrade

so one bar then h plus equals one molar solution ok
 so this
 completes the standard hydrogen electrode part and it is your
 right hand electrode where sorry this is your left hand electrode this is
 the left side you will be putting you can also put it in the right right hand
 side in that case
 in that case you have to be careful about the sign but anyway that is not the
 problem ah
 so anyway
 for for simplicity we are putting the standard you know half cell in the left
 hand side and the
 unknown half cell in the right hand side you can do in the other way that is
 not a problem that
 you have to do it every time that ah that s h e has to be put over here you
 can also put
 it over here and this one can be over here ok
 so left hand electrode standard hydrogen
 electrode and here oxidation is taking place now couple this with the copper
 electrode
 so put a double vertical line c u two plus equals one m then c u solid
 so this
 completes the cell this completes the cell that you have completed it and
 then
 what you have to do ah you measure the this emf of this cell of course this is
 zero so
 whatever value you'll be getting as emf of the cell will just be equal to this
 one that is that
 that will be equal to the reduction potential reduction potential of this ok
 so that is why if
 you want to know the reduction potential of your unknown electrode you should
 put that in the
 reduction in the reduction side that is your right hand electrode side because
 the customary
 that in a customary it is that the that that in the right hand side reduction
 is taking place and
 the left hand side the oxidation is taking place ok
 so therefore and if you measure at 298
 kelvin you will be you will be getting you will be getting some value and
 it is found that the value e cell which is equal to phi right which
 is found to be equal to 0.
 34 volt at this temperature condition
 so therefore
 the reduction potential of this half cell is like this okay
 so so therefore therefore
 ah this particular reaction that is cu 2 plus equals 1 m plus two electron that
 gets you cu 0 solid
 so that has got this much
 so this
 much of volts
 so so if you want to if you want to you know express this in terms of delta g
 then
 delta g will be delta g will be equal to minus n f e
 so since e is positive this e e cell is
 positive

so therefore this ΔG for the process because it is $E = 0$
 so $\Delta G = 0$
 so therefore
 this will be positive
 so this side
 so ΔG zero bar will be negative
 so therefore
 this process will be spontaneous as it is represented like like copper two
 plus
 two copper it is a spontaneous process ah under ah the this this ah total cell
 reaction
 where this is the half cell half cell reaction ok
 so other side of the cell i mean is the is ah is the oxidation oxidation of
 hydrogen to
 h plus okay
 so the total cell reaction i mean this one this absolute reaction plus this
 subsoil reaction if you add them together then the corresponding ΔG zero
 will be less
 than zero it is less than zero means means it is spontaneous that that means
 if your cell potential
 or cell emf is positive then then the net cell reaction is a spontaneous
 process net cell
 reaction is a spontaneous process now similarly ah what will happen for the
 how will you
 get how you get the value for i mean the half cell potential for for this zinc
 zinc
 two plus system the same prescription is same that you construct a cell which
 is platinum solid
 you couple with hydrogen electrode H_2 gas then one bar pressure then h plus h
 plus
 equals one molar then zinc two plus equals maybe one molar then zinc solid so
 for this one this is your left hand electrode this is right hand electrode
 so if you measure the
 emf of the cell with the help of this compensation method i just have
 discussed a little bit so
 it is found that for this the cell potential since it is 1 bar then 1 molar
 so it is and 298 kelvin
 so standard cell potential is found to
 be zero point minus zero point seven six volt ok
 so that means the the half cell potential
 for this one this particular reaction ok
 so reaction is like this plus twice electron that gets using ok so
 half cell potential for this $\phi_{Zn^{2+}/Zn}$ is equal to is equal to minus 0.
 76 volt okay
 so so
 what what is the message message is your ΔG is equal to minus $n F E$ zero
 so since this $E = 0$
 is negative over here
 so therefore your ΔG will be this ΔG will be greater than zero
 so basically it is a ΔG at t p is is zero i mean i mean greater than zero
 means it is it is
 i mean it is not a spontaneous process as it is represented but the reverse
 process is spontaneous
 okay

so therefore therefore ah what will happen what will happen that now if we couple this couple this together what is going to happen although this half cell if you consider this half cell on rehab cell reaction then this is not i mean the way it is represented i mean zinc to plus to zinc it is with with a negative value of potential so therefore this reaction is not going to happen what is going to happen is the is the is the is the other way around okay so therefore ah therefore um what what is the situation that ah that therefore ah the cell potential for this one is minus and the other one that is for the copper one is plus so now if you now if you couple this two together then this situation will be a little different ok so couple this ah together means couple if you couple then your ah this ah daniel cell okay if you couple this together like this daniel cell ok if you couple like this if you couple like this ok so therefore zinc solid solid zinc sulfate c equal to one CuSO_4 cu okay so now you are putting this putting this in the left hand electrode and putting this in the right hand electrode what is going to happen so the reduction potential for this is ah what is the value so it is 0.34 volt and this is minus it is minus this value is minus 0.76 okay so therefore e cell will be ϕ_{right} means $\text{Cu}^{2+} + \text{Cu} - \phi_{\text{left}}$ means zinc two plus zinc so that means 0.34 minus minus 0.76 volt that gets you one point one volt ok so you see that when we when we add this appropriately i mean when we ah you know combine these two electrodes accordingly we add their respective reduction potential then we get this value recall our earlier classes where we also have stated that its cell potential is 1.1 volt so 1.1 volt is coming i mean the contribution is coming from this copper electrode and this much is coming from the from the zinc electrode okay so the positive value of the half cell potential say for example positive value of the half cell potential for say copper system $\text{Cu}^{2+} + \text{Cu}$ plus $\text{Cu}^{2+} + \text{Cu}$ plus say c is equal to one concentration equal to one so indicates that what does it indicate in it indicates that so

the reduction potential is reduction potential is 0.
 34 volt that means corresponding and reaction
 is $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
 so the value of the of the potential is positive
 means this process is spontaneous as it is represented that means reduction is
 a spontaneous
 process for this
 so that is why this electrode is kept in the kept as the right hand electrode
 okay
 and therefore therefore ah the i mean copper can easily easily getting reduced
 to ah copper two
 plus can easily ah can easily become copper zero ok
 so so and um
 so easily it can be reduced
 but compared to compared to hydrogen plus ok why compared to hydrogen plus
 because we
 are calculating we are estimating with respect to this hydrogen electrode ok
 so that means
 H^+ plus cannot oxidize copper to this process under the standard condition as
 stated ok
 so so therefore that is why this copper does not dissolve in hcl under
 normally i mean under normal conditions ok now in the in the other case the
 negative
 reduction potential for zinc system zinc zinc two plus e^- equal to one
 so minus zero point
 seven six volt ok
 so so it means it means that the reduction potential for this system means
 that it indicates that H^+ plus ion can oxidize can oxidize zinc to zinc to plus
 or zinc can
 reduce zinc can reduce this H^+ plus to H_2 okay
 so so that means that means reduction of copper
 to two copper zero by H^+ plus is not possible but but you know you know
 reduction of H^+ plus
 to H_2 or you know oxidation of zinc to zinc plus ok this one is possible
 that means this
 is negative means we are representing the reaction zinc two plus plus twice
 electron
 zinc 0
 so for this this is the value this is negative means corresponding delta
 G° is positive
 so the way it is represented this is not a spontaneous direction but
 the reverse is the spontaneous direction okay
 so zinc will dissolve zinc will dissolve in
 in hcl producing hydrogen
 so therefore zinc will reduce H^+ plus two hydrogen and correspondingly
 correspond or in other words ah in acidic condition zinc will be oxidized to
 zinc two
 plus ok
 so therefore that is why considering considering all that that its reduction
 potential
 is plus 0.
 34 and its reduction potential is minus 0.
 76 we are putting this zinc electrode as the
 right hand electrode and the copper electrode as the left hand electrode as as

i already have shown
 you the representation of the of the danial cell okay
 so now ah we will now come to different i mean some examples of ah different
 types of
 ah electrodes one example will be like like hydrogen electrode say for
 example
 hydro electrode h two electrodes okay hydroelectrode is basically the your
 standard
 hydrogen electrode or may be simple hydrogen electrode ok or maybe say for
 example you know um
 say chlorine electrode or may be bromine electrode bromine electrode is
 basically platinum it is
 metal dipped into a solution like br_2 aqs then br^- minus aqueous okay
 so so this is called the
 bromine electrode or maybe you can replace bromine by chlorine and chloride it
 will be a chlorine
 electrode
 so basically the reaction is $\frac{1}{2} \text{br}_2$ aqueous plus electron that gets to b
 or minus ok
 so so this is ah this is in the reduction
 scheme ok
 so therefore this is one electrode another may be like say for example silver
 silver
 chloride electrode like like you dip silver wire in silver nitrous solution
 so it will be a g
 solid then a g plus say c equal to some value that's a metal metal salt here
 it is gas i
 mean platinum electrode i mean hydroelectric where where hydrogen is is
 basically in the
 form of gas
 so basically the equilibrium is $\frac{1}{2} \text{h}_2$ and h^+ plus here it is a g a g plus in
 the
 same various other electrodes are also possible ok
 so ah
 so therefore therefore um this can be
 representation also may be say for example ferrous ferric system
 so what will you do
 so reaction is
 fe^3+ plus plus electron that gets to fe^2+ plus
 so it is nothing but you have ferrosynpheric
 mixture and you dip one platinum where into it or maybe maybe say for example
 you have you
 have other options like say one material which is reversible with respect to
 some ion
 like say for example silver silver chloride reversible with respect to
 reversible with
 respect to chloride
 so what is the reaction ag agcl plus electron that gets you a g zero plus cl^-
 minus
 so silver silver chloride reversible with respect to chloride okay so
 basically it is represented a g a g c l solid cl^- minus ok
 so its representation
 is like this
 so depending on i mean whether it depending on its reduction potential either

it has to be put on the on the left hand electrode or maybe on the right hand electrode so that the overall cell potential is positive and as a result of which the overall sale reaction is spontaneous but suppose if you if you represent in an arbitrary way i mean you you don't suppose you do not care about about ah where to place i mean whether you will place the appropriate you know half cell in left hand side or in the right hand side then what you do you place wherever you want to place whether in left hand side or maybe in the right hand side then finally you you calculate or find finally you estimate the cell potential if the cell potential is coming to be to be positive then the way you have represented is the right one but if your cell potential is coming to be negative then you should reverse the half cells that is this up cell will go over here and the this absolute go over here over to the right hand side to get you the positive you know positive cell potential ok now um next is the what is the relationship between the electrode potential and concentration of the electro active ah substances now recall that while we were discussing this standard electrode potential then it was assumed that your that your electroactive substance that means the electrolyte the concentration is kept to unity so that whatever you know half cell potential you are getting is will be called as the standard reduction potential at say 298 kelvin ok now if we if we apply thermodynamics while evaluating the delta g of the chemical process then from thermodynamics we can write because we have to we have to make use of this expression that delta g is equal to minus n f e e cell and if you plug in this information to the to the delta g expression for a chemical reaction suppose that chemical reaction is operative in the in the electro chemical cell then you will end up in getting ah one expression which is known as the nursed expression nursed equation and for half cell you can write like this ϕ_m in plus m is equal to $\phi_\theta - n$ plus m minus rt by $nf \ln$ concentration of m divided by concentration of m n plus actually the expression was developed with ah with the in here in in the numerator and denominator expression was developed with respect to the activity activity of m and activity of m n plus but for dilute solution you

know you can replace activity with concentration that's why we are writing
 like this otherwise true expression is the ratio of the corresponding activities now
 r is the gas constant t is the absolute temperature n is the number of electrons
 n is the number of electrons that are involved in reducing the species that means m
 plus plus in electron that gets you m
 so n number of electrons are involved in this reduction process f is the faraday it is approximately 96500
 coulomb per mole 96500 coulomb per mole ok
 so therefore therefore you know for solids and gases or if it is in the pure state of aggregation the this one this this numerator will and
 i mean for all practical purposes you can you can take this to be equal to unity okay that means activity is taken to unity for pure state of aggregation
 so therefore we can write ϕ_m
 plus m that will come out to be equal to $\phi^\ominus_m - \frac{r}{n} \ln$
 $\frac{m}{m^\ominus}$ one upon concentration of m ah n plus ok
 so where ah you know r is the value of r is eight point three one four joule kelvin inverse mole inverse for the value of r okay and f is 96500 okay
 so and here it is the constant molar concentration mole per liter ok
 so so this is the expression now you see that the value of ϕ the value of ϕ means it is not the standard but this is the standard potential
 so value of ϕ will depend on a constant quantity at a given temperature say 298 kelvin it will also depend on the concentration of this species
 so if it is changed then accordingly the value will be modified okay if it is changed so therefore it depends on this one it also depends on the temperature
 so that is why that's why in electrochemical experiments temperature is is very important quantity because ah because temperature if you change temperature automatically standard states and everything i mean with respect to standard state the your state of measurement will be changing
 so therefore this ϕ will be changing
 so therefore temperature is important and maybe ah for changing temperature the change in ϕ ah you know may not be that huge but still there there will be there there can be some some change in the value of ϕ as you change the temperature ok
 so this is basically the standard reduction potential and this standard reduction potential how to measure i already explained to you ah i mean while discussing ah the construction of cell with standard

hydrogen electrode ok so

let us look at some standard electrode potential reduction potential at 298 kelvin of some

some you know substances

so standard electrode potential at 298 kelvin and your E^\ominus in volt okay

so if the reaction is $F_2(g) + 2H^+$

so we

will just discuss with the reaction involved that is the reduction reaction involved to

F_2 minus its value is two point eight seven then take another $H_2O + 2H^+$

plus twice electron that gets you $2H_2O$ ok its value is one point seven eight ok $Cl_2 + 2e^-$ that gets you $2Cl^-$ minus its value is one

point three six volt $MnO_2(s) + 4H^+ + 2e^-$

electron that gets you $Mn^{2+} + 2H_2O$ its value

is one point two three volt $Cu^{2+} + 2e^-$ that

gets you $Cu(s)$ its value is 0.

34 okay $2H^+ + 2e^-$

it is H_2 it is assumed to be i mean at all the temperatures one at one

bar pressure it is equal to zero $F_2 + 2e^-$ is zero if you

solve it it is minus zero point four four volt zinc $Zn^{2+} + 2e^-$ that gets

you zinc solid it is minus 0.

76 sodium $Na^+ + e^-$ that gets you any

solid minus 2.

71 then lithium $Li^+ + e^-$ that gets you

lithium solid it is minus 3.

05 volt ok

so you see that there is a change over from i mean

it is the reduction potential reduction potential

so i have expressed the reaction as the reduction

reaction you see it is all represented as a reduction

so reduction potential you

see that the value is reducing this way value is reducing this way

so positive value

of the redox couple with respect to

so it is positive means positive with respect to zero

negative means negative with respect to zero

so positive means it is a weaker reducing okay it is a weaker reducing agent compared

to hydrogen negative means it is a stronger reducing agent than hydrogen hydrogen

means this you know $H^+ + \frac{1}{2}H_2$ system

so that means you can see

that higher the value higher will be the system will have higher tendency larger tendency to

remain in the reduced state higher the value higher the value in absolute sense because you have to consider

both i mean the the numerical value as also the the sign okay

so higher the value higher

will be will be in the that will be the tendency to be reduced you see that fluorine gas

so its that in reduction scheme it is fluorine to fluoride it is plus 2.
 87 consider
 this one for hydrogen okay
 so that means it is a positive value the system will
 have will have the higher tendency much higher tendency to remain as fluoride
 so that
 means it will be a very strong oxidizing agent ok it is a very strong
 oxidizing agent and weaker
 very weaker reducing agent compared to this ok
 so as you move on to hydrogen towards the
 hydrogen you see you see that these values are reducing that means they are
 oxidation oxidation
 power i mean um the tendency to oxidize other material it is reducing ok and
 then it is you know
 with respect to hydrogen it is zero means it is in the in the in the balance
 point and then if you
 move on to this side you see that sodium you see its value is negative its
 half cell potential
 is negative absolute potential negative means that corresponding phi value is
 negative means
 the delta g value for this particular process is positive positive means the
 way it is represented
 that n a plus two n a this reaction is not spontaneous however the reverse
 reaction is
 spontaneous okay that's why that's why you know it is it is two point ah seven
 one with
 negative means it will always try to remain as sodium plus that is why you
 have to keep sodium ah
 metal inside kerosene
 so that you know it does not get it does not get contact of water or some
 other region
 so it it is it is very reactive in the same way this is also very reactive
 so
 here this side is reactive here the left hand side is reactive depending on
 whether your this
 e zero or it is basically phi zero i should write phi phi zero this phi zero
 ah is negative
 or or or it is negative or it is positive ok next is
 so now ah for for daniel cell we we
 started with daniel cell
 so for daniel cell ah for daniel cell cathode cathode means it is right hand
 electrode
 where the you know reduction is taking place ok
 so phi c u 2 plus c u is equal to
 phi naught c u 2 plus c u minus rt by twice f because 2 electrons are involved
 ln
 this 1 by concentration of co2 plus equals anode left hand electrode oxidation
 phi z2 plus zinc we are using the reduction potential values
 thats why it is i mean first zinc two plus then zinc zero
 so process is from here
 to here
 so phi 0 zinc to plus zinc minus rt by twice f l n one by
 concentration of zinc two plus equals ok
 so therefore what we

get what do we get we get e cell what do we get we get e cell is equal to again
 same thing if i write minus phi left
 so this is u pack as per you pack and reduction potential okay
 so therefore it is phi right minus phi left means this phi
 $\text{Cu}^{2+} + \text{Cu} - \text{phi}_{\text{zinc}} + \text{Zinc}$ okay
 so you just plug in this information you
 write this one first
 so that means phi naught $\text{Cu}^{2+} + \text{Cu}$ then write minus r t by two f l n
 this Cu^{2+} plus equals this okay
 so this
 gives you this part 5 i mean this one minus this one minus this one minus
 this one minus phi naught zinc to plus zinc okay and then minus means this
 will
 be plus plus r t by 2f l n this this 1 by 1 by zinc two plus aqueous ok
 so this together ok will get you
 so therefore you can write e cell e cell equal to
 so e cell means this one
 and then this one
 so bracketed one will be you know basically E^{\ominus} cell because
 it is the difference in the standard electrode potentials and then e cell
 is zero cell minus r t by twice f l n zinc to plus equals by copper to plus
 equals
 so
 so this is the expression for e cell when you consider this you know this
 daniel cell
 ok
 so daniel cell means it is it is basically the reaction is ah basically you
 know in the right
 hand side there is reduction in the left hand side it is oxidation
 so net reaction is that
 so in one
 electrode this zinc to zinc plus is happening in other electrode copper to
 copper copper plus
 two plus two copper zero
 so zinc plus CuSO_4 that gets you zinc sulphate plus cu okay
 so so and
 since ah since these are pure state of aggregation their corresponding
 activity or concentration
 value can be taken to unity
 so therefore you see that e cell depends on temperature and also
 depends on the ratio of the electro active or electrode active species or the
 or the electrode
 with which i mean it is reversible that is the ion with which or against which
 this electrode is
 reversible
 so it depends on the concentration of that
 so if you plug in the value of r if and if
 you put t is equal to ninety eight kelvin then you will end up e cell is equal
 to e zero bar
 cell minus zero point zero five nine by two log zinc 2 plus equals by cu 2 plus
 equals
 so this
 is the expression expression for the e cell for the daniel cell okay
 so what we have learnt

so we have learnt in this particular piece of lecture that with the help of standard hydrogen electrode coupling with standard hydrogen electrode and if you construct a cell with unknown half cell then you will be able to find out the half cell potential and then with this information about the various the information means information of various half cells then you can pick up specific half cells to construct different type of types of cell where the total cell reaction will be the combination of individual half cell reactions ok so this much for today in the next lecture we will take up some examples and some applications of this emf measurements and some other aspect of this electrochemistry so till then thank you