

good morning everybody welcome to the second class of this redox reactions where we are

so far discussing about the corresponding fate of two very important species one is the water molecule and another is the dioxygen molecule and since we are talking about the reactions which are either a reduction reaction or a oxidation reaction and we have also seen in the previous class that utilization of photosystem 2 which is a typical natural process and nature is responsible for utilization of water molecules for the production of the glucose with the elimination of this dioxygen molecule and we definitely know there that whenever we produce some amount of this glucose molecule at the end when we require this glucose as our source of energy as our very survival we utilize these glucose molecules for the synthesis of atp molecules also and these atps are our energy currency for all living system including the human being

so when the glucose oxidation is taking place for the production of carbon dioxide and water we all know

so these two reactions are very much interrelated in terms of electron transfer so these electron transfer reactions are that's why

so important and we should always know how this electron transfer is taking place and related to that electron transfer reaction we all know starting from the electrode reactions the electrode potential or the redox potential

so we also know that something is also related to these as the different redox potential values then they are related to  $\Delta G^\circ$  values then heat of reaction and all these but the main driving force for all these reactions are the typical electron transfer reaction in a particular direction

so if this electron transfer is going from the species that means the species is losing electron we call it oxidation and when the species is accepting that electron we call it a reduction

so all these thermodynamic quantities and all these thing because we can find out these by doing experiments also because knowing this chemistry phenomena is always related to the experiment because we do the experiments and experiments will clarify some of these things

so this electron transfer reaction if we utilize it for water or the dioxygen there will be heat transfer also and the very basic thing what we know for these reactions is the corresponding energy which is released

so some of these reactions are exothermic and at the other hand some of them are endothermic

so the reaction will definitely tell that whether you have a situation where energy will be released or energy will be absorbed

so if we just simply go back to this condition that means that how this water is getting oxidized and how  $O_2$  can be reduced or  $O_2$  can be utilized for some other purpose such as that simple combination reaction where we utilize this for attaching this  $O_2$  to some other species such as a is attaching with  $O_2$  forming some cases  $AO$  or  $AO_2$  such as if a is carbon c then we can have carbon monoxide and carbon dioxide formation and at the same process since the carbon is getting oxidized due to the formation of carbon monoxide and carbon dioxide carbon can function as a very good reductant

so in that particular reaction we see that the carbon can function as a very good reducing agent which can be utilized very nicely for the metallurgical processes that will see afterwards

so if we see that water can function as an oxidant

so if water is there which is a different proposition that we know that water this particular thing that in the ps2 that is basically water is getting oxidized but if we consider in a different fashion that how water can function as an oxidant

so the transfer of reaction is of different type and the reaction of water with the species a say sodium if it is sodium is of different type and in this particular reaction it is not that this will release dioxygen molecule from water it is not the oxidation of water molecule but it is the function of water as an oxidizing agent which will oxidize the sodium metal from  $n a$  to  $n a$  plus and the fate of reaction is also twofold one part is going as the producing hydroxide ion the medium will be alkaline as a result what we see that if we consider that  $n a$  plus and  $o h$  minus attaching together and they are in aqua solution

so we get basically sodium hydroxide formation with the evolution of hydrogen so water serving as an oxidant will be releasing some amount of hydrogen from the water

so hydrogen what is present in water we know that from the typical ionic picture of water that water is attached to one oxygen by two  $h$  plus

so this  $h$  plus is always present in the water

so in aqueous medium if it is there

so that  $h$  plus will be reduced and the electron transfer can take place from  $n a$  plus

so  $n a$  plus will give that electron to  $h$  plus producing hydrogen atom first then in the corresponding molecular form of the hydrogen that means the dihydrogen will be forming

so if we now consider two other things that if we have the water molecule itself and if we consider in terms of the corresponding electron transfer potential that oxidation of water if we consider that simple oxidation of water what we find in the photo system two

so that particular water will be utilized for the production of the dioxygen molecule through the formation of the  $o o$  bond that  $o o$  bond was not present in the isolated water molecules

so if we have that isolated water molecule present

so we must have at one position that we can establish some  $o o$  bond

so electrons are being posed to the molecular orbitals of this water molecule and we have a large number of electrons producing in this fashion if they are giving  $h$  plus as well as electrons

so these electrons are there

so that particular electrons what we produce from these water molecules can be utilized for the reduction of this  $h$  plus formed over there producing the hydrogen

so for water we know that at  $ph 0$  we know that the electrolysis of water all we know

so at one electrode we know that we produce oxygen and another electrode we produce hydrogen and this  $e$  zero values

so this is the standard hydrogen electrode value which we consider as zero point zero zero

so if we set the scale at zero point zero zero volt versus normal hydrogen electrode and with respect to that scale we just consider that other that means the water where the water is present for this particular reaction

so depending upon that particular reaction what we find that where water stands against that of the hydrogen electrode

so it is 1.

35 of 2 3 volt versus  $nh$  which is quite high or quite above this particular scale

so overall if we adopt these two steps of reactions one is the oxidation and another is the reduction if we add up the overall reaction what we get is two  $h$  two  $o$  giving rise to two  $h$  two plus  $o$  two and once we find out the  $e$  zero for

the cell definitely it is a cell reaction for electrochemical cell where we have the cathode and anode and oxygen and hydrogen will be liberated in respective electrodes and that particular liberation will give rise to a driving force for that particular cell reaction

so e zero cell for that reaction is one point two three four by simple adding up of these two half cell reactions and the delta zero for this reaction delta g zero for this reaction is minus four seventy five kilo joule per mole

so this is the basic or the standard scale where we just fix all these things and where we get these values for the corresponding transfer of all the different electrons

so if we see that this particular thing is happening in a different way when sodium is directly reacting with water

so sodium is functioning as a good species which will provide electron to the water

so basically this water is very much close to the cathode because we all know that the cathode is giving electrons

so if it is the cathodic reaction is nothing but the liberation of hydrogen

so this liberation of hydrogen will take place at cathode

so at the cathode the reaction is this and your  $E^0$  value is 0.

00 volt versus nhe

so this particular reaction that means what about the  $E^0$  value for the other reaction

so this we know that the conversion of water to a hydrogen

so it is a particular half cell reaction

so what about the other species which is reacting with the water molecule is the sodium metal this is  $n a$  and  $n a$  is transferring to  $n a$  plus and he has a typical or natural tendency for producing this  $n a$  plus and in that particular formation of this  $n a$  plus we get that a corresponding electrode potential for  $n a$  to  $n h$  plus

so that is basically a typical oxidation process and that oxidation process will have certain amount of values for our  $E^0$  values

so this particular thing is a completely different one if we find this reaction when we see that particular reaction when going for  $n a$  to  $n a$  plus which is a typical oxidation reaction and the electron is being supplied by the sodium metal

so what about the nature of this particular transfer potential

so the reaction of sodium which having a negative standard potential

so all these alkali metal ions

so immediately one we see that we have a negative standard potential for this particular reaction we should always think about the corresponding positioning of this  $n a$  in the periodic table

so in the periodic table it is in the group one element where it is in the alkali metal where we all know that the lithium sodium potassium rubidium cesiums are there

so they will have some correlated reactivity pattern where they immediately can go from  $n a$  to  $n a$  plus  $k$  to  $k$  plus

so these all alkali metals have a inherent tendency that it can react with the water molecule in a similar fashion which will be able to release hydrogen from all these water molecules

so this is one kind of reaction and it is a typical example a completely well known and well established example a textbook example for water functioning as an oxidant

so what about this functioning of this water as a reductant that means what when we talk about something that how we have a typical species

so one particular species we can have and that particular species in this particular discussion it is the water molecule and any other species will find in this universe that whether we will be able to take out electron one or more or we give or inject some electron to this particular species

so how much these all are stable

so that is very much important in relation to the same species which we are considering as a

so if a is losing that electron a will be giving you a plus and if a accepts one electron we get a minus

so what about these things basically the availability of these species the a which is in the zero state or in the nasives native state or in the elemental state or its corresponding cationic version or this corresponding ionic version

so that is very important

so if this particular species what we get during the reaction of these

so whether this same water molecule can function as an oxidant or can function as a reductant

so depending upon this particular reagent

so these are all we know that they are these are the reagents or these reagents are the species which are functioning as an oxidant or reductant

so all these things that means related to all these our redox reactions is that our oxidants and the reductants are the reagents in a similar way or in a similar fashion what we can consider that our electrodes the cathode and the anode

so those electrodes cathodes and anodes can also function as a reagent and in that particular case what we find that a chemistry which can be controlled by electron transfer coming completely from electrodes are known as the aspects of electrochemistry

so in this particular case if we just consider electrochemistry will be dealing with the electrodes

so we can have the cathodes and the anodes and what we can have that we can electrochemically oxidize this a to a plus or electrochemically we can reduce a to a minus but there are some reactions and all the chemists always interested to know some chemical reagents

so chemical reagents will be there what we can use for oxidizing or reducing a particular species such as a

so there will be utilizing the oxidants and reductants these are all chemical species

so some species which can be utilized for oxidation reaction which can be utilized over here and this basically will be responsible for the oxidation of a like that of our electrodes similarly if we use reductant for this and if this particular transformation if it has a facile electron transfer potential a will be going to a minus through the addition of the reductance or the reducing agents at this particular point

so what about this water

so we are talking here as that water will be using at a reductant

so water itself will be reductant

so some species will be there which can function as an oxidant during the reaction of this  $\text{H}_2\text{O}$

so this textbook example for this water as a reductant is therefore that we get here that this particular water as a reductant where we get this as  $2\text{H}_2\text{O} + 2\text{F}_2 \rightarrow 4\text{HF} + \text{O}_2$

so this is a typical example of oxidation of water molecule where fluorine is the oxidizing agent

so we all know that fluorine as the extreme right hand corner upper right hand

corner of the periodic table it has the highest possible electronegativity what we seen in my previous class now we see that it is also functioning as a very good producing agent which can be able to oxidize the water molecule how because this  $F_2$  has the highest possible electronegativity

so it can very nicely accept the electron from the water molecule because we know that the water molecule during some oxidation can give rise to a large number of electrons

so these four electrons are coming out from two water molecules

so these electrons if they are attached to the fluorine atoms fluorine atoms will be converted to the fluoride and your oxygen will be liberated as typical dioxygen molecule which are derived from  $H_2O$  where  $H_2O$  this O is present as  $O^{2-}$

so as typical ionic model

so what we get as O is present as  $O^{2-}$  which is the oxide ion

so that will be losing two electrons

so per  $H_2O$  water molecule we have to use or transfer these two electrons from this O  $^{2-}$  and that O  $^{2-}$  will be giving you O zero or only the oxygen atom the necessary and oxygen atom and two nascent oxygen atoms forming over there and that can be attached to another oxygen giving rise to the dioxygen molecule for this

so this particular point what we should be able to say that depending upon the corresponding tendency or the strength of the oxidizing agent and the reducing agent we can have two different types of reactions on the same substrate your same substrate that means the water as the substrate

so water can be oxidized or water can be reduced and we get different interesting reactions what we are just talking about the corresponding formation of this oxygen molecule and the consumption of that oxygen molecule for the ps2 that means the photosystem two and the burning of the food material

so if we just consider that a typical tendency that some of these reactions like that of our n a sodium metal that can also be true for alkaline earth metals such as magnesium

so here is an example of this magnesium

so magnesium we know that is the metal

so we can have a metallic rod of magnesium and that mechanic rod how it goes because the metallic rod can be dipped in simple water molecule and that can also be dipped inside a solution containing silver ions that means the collision containing silver nitrate

so what about this particular reaction

so we are thinking something where we are trying to consider that the reaction of  $Mg$  with a  $Ag^+$

so will there be any competition for this electron transfer reaction that means what we are looking for here is that  $Mg$  when reacts with a  $Ag^+$  that means the silver ion the silver one the silver ion whether that silver ion can be able to oxidize this particular magnesium

so silver ion will be the oxidizing agent or oxidant which can accept the electron from the magnesium rod and itself can be reduced to silver  $^0$  and magnesium will be oxidized to magnesium  $^{2+}$  and the reaction stoichiometry will definitely tell us because we have to balance the number of electron transfer from left to right during the reduction of silver plus that means silver ion as one plus we require one electron transfer but for the oxidation of  $Mg$  we require transfer of two electrons

so the stoichiometry would be one is to two

so if we go from left to right we see that some amount of magnesium will be coming into the solution

so it is not that color but is a there will be something some color change can take place if there is some other metal ions which can give rise to a coloration by going to the solution and silver what is forming where the electron transfer is taking place on the rod itself because this is the contact point where magnesium rod is in contact with the silver ion

so the silver ions will be deposited over here and some amount of magnesium rod will be decayed

so this is the thing what we can think of in a different fashion what we are discussing in our previous class that how corrosion can take place how rusting can take place on the iron

so this is also of some type of that particular corrosion reaction where some amount of magnesium rod is getting degraded some amount of magnesium rod is corroded but not in presence of only water and atmospheric oxygen or moisture but in presence of a g plus

so the metal ions which are present in these water molecules is also critical or crucial because we all know that all water are not pure h<sub>2</sub>o suppose sometimes we find that the industrial influence what is being discharged by industry having several or large number of metal ions present in it and sometimes we do not know what are the metal ions present in that particular industrial effluent

so if something some species metal rod or metal pipe or metal strip or metal seat is there in contact with that water environment which is back which has large number of metal ions including the silver ion or any other ion which is oxidizing

so the rod in contact with that water which is not pure water at a particular ph

so this can basically degrade this

so it is another level of this particular corrosion reaction where we find the rod will be degraded because this rod will be leaching out the magnesium rod will be leaching out as magnesium 2 plus and if there is the possibility this particular ion will be directly deposited over there as the silver metal or the silver 0 otherwise it can form oxide in presence of oxygen or water molecule and will be degraded out from this and has formed as a typical sediment over there

so this thing that means if we get instead of this particular thing that means the oxide formation

so what we have seen in our previous class that rust what is forming is fe<sub>2</sub>o<sub>3</sub>

so this particular one

so this rust is basically forming from iron metal and this iron metal which is not

so high in that particular e<sup>0</sup> values

so this particular one will be weakly electro positive metal

so if it is weakly electro positive metal and it can give rise to the electron transfer reaction to give you ferrous and ultimately to the ferric and these oxide ions which are producing from water molecule will lead rise to this fe<sub>2</sub>o<sub>3</sub> which is our rust

so that we have seen

so in a similar way that we just say that these oxides these oxides which are having something where the weakly electro positive metal ions they basically decompose also when heated to high enough temperatures

so this is a different proposition of a different aspect what we are thinking that now we have some oxide and that if that oxide we heat it at high temperature what will happen because here we are seeing that the metal is getting degraded by the formation of ions by the formation of hydroxides or formation of the oxides

so if we take some amount of oxide because it has a direct correlation with the

metallurgical process where we find that the hydroxides will ultimately giving you hydrated oxides and that hydrated oxide it can be treated by some reducing agent to give you the metal back

so this particular process is also very much interesting to know that whether these oxides can decompose at high temperature

so that is a very classic example of the decomposition of  $HgO$  the mercuric oxide in the inorganic chemistry laboratory classes also we see that whether we have a sample of mercury mercuric oxide whether we can identify by doing the reaction of this particular change where if it is heated it can be decomposed into the oxygen and the mercury metal itself that means the oxygen will be eliminated from the system

so that is reverse reaction of that of our combustion reaction

so combustion reaction is another kind of redox reaction what we know that any species or any metal which is a which can be converted to  $AO$  or  $AO_2$  similarly any non metal like carbon if it can be oxidized to carbon monoxide and carbon dioxide

so the reverse reaction of that is that if we take the oxide any oxide any metallic oxide any non-metallic oxide any carbonate any sulfate whatever it is if we go for or if we treat it at high temperature what will be the fate of the system or what will be the fate of that particular compound that we should always keep in mind and when we are in this particular class of this redox reactions we should always consider that whether some amount of electron transfer can take place

so the heating of  $HgO$  is the simple heating of  $H_2O$  itself but if we use something where we have some reactive metal we can use

so the reactive metal like zinc is used with that of your cupric oxide and this particular case is what we state that the more reactive metal displaces the less reactive metal from its oxide also

so in this particular case the more reactive metal is our zinc

so the reactivity of zinc is higher than that of our copper in terms of the electron transfer reaction but it is a simple very simple observation very simple reaction where we consider it as the removal of this oxide from copper to zinc

so if we want to go for some reaction that means a metallurgical process of any oxide not that it is the copper oxide

so any oxide if we can have and if we want to get that particular metal from this particular oxide that means the copper from copper oxide or cupric oxide

so zinc zinc metal strip zinc powder zinc granules can function as a very good reducing agent which can reduce this particular cupric oxide to produce copper and itself can go for zinc oxide

so large number of reactivities we can find even in organic chemistry we find the use of this zinc as a very good reducing agent but here we are classifying this as a preliminary language that is a typical displacement reaction where oxygen is getting re displaced oxygen is being removed from copper site to the zinc side

so if we consider three dimensionally the solid state structure of this copper oxide which is a type of solid state structure of this cubic oxide

so we will find that afterwards which basically the structure will also be changed because we will have a metallic structure of copper metal is itself and zinc is going from zinc to zinc oxide structure which has a another type of solid state structure which are the oxides of these metals

so this particular reaction has a direct correlation with that extraction of some amount of elements

so this can this reaction can be directly written for the extraction of copper

from some copper ore suppose our copper ore is we are getting from the nature from the earth crust as copper oxide

so after enrichment after purification what we find that a certain level of concentration we can reach and if very pure copper oxide can be in the final stage can be reduced to copper metal and this process can be considered as an extraction of copper from its copper mineral which is copper oxide

so this particular reaction

so always because in this case the copper is present in the bivalent state in the cupric state that will be reduced to copper zero

so extraction of these elements definitely also requires

so metallurgy is also largely dependent on all these redox reactions

so metallurgical processes are also dependent on redox chemistry and the thermodynamics and the kinetics of that particular electron transfer reaction is also important because we are considering something with appropriate potential values

so we have to use a typical oxidizing agent or the reducing agent for this transfer in this particular case what we are using zinc for the reduction of cupric oxide is zinc as the reducing agent but it should be appropriate one because the potential is matching thermodynamically it should be matched for this particular reduction reaction otherwise we can have some other metal aluminum we can use or some non-metal like carbon carbon reduction processes are also known for all this metallurgical extraction

so what we find that in this particular case that if we have some examples of these metallic and some non-metallic species and if we consider that simple electron transfer reaction starting from a single electron to a triple electron transfer reaction we see that by simply looking at the half cell reaction because we are considering here we are considering that we have the magnesium rod which is having a potential of minus 2.

36 volt because this is the quantitative picture what we have seen

so far from a reaction where we have seen that the magnesium rod which is being dipped in a silver solution silver nitrate solution silver ion solution

so this is the quantitative picture which we can get that magnesium when the rod is being dipped inside a silver ion solution

so this particular magnesium rod will go into the reverse direction because it has a potential of 2.

36 volt in the reverse direction and this particular silver ion will be reduced

so silver ion will be reduced back to silver because its potential is 0.

80 volt only and magnesium metal will be oxidized to magnesium 2 plus

so in all these examples

so only few examples we have given starting from the electron transfer potential values from the lithium which is the strongest reducing agent of minus 3.

05 volt to the strongest oxidizing agent which is fluorine

so that we have seen in our previous class by looking at the periodic table periodic table this is the left hand side of the periodic table where it has electro positivity and on the right hand side we have seen the corresponding electronegativity that means the electronegativity is also high and it accepts the electron very easily that is why this electron transfer potential is also very high for this reduction of fluorine to fluoride ions which is 2.

874 that's why we have seen that the reaction of this  $F_2$  with water

so if we just consider this water potential is not here the zero values for the water oxidation as well as reduction is not there but we can have some rough idea or knowledge that what is the corresponding potential of this water for its oxidation and reduction we can correlate how these non-metals and metals will

also react with water in a different fashion and also the different metal ions how they react if we just simply tabulate this is a very simplified table where it gives with respect to the reduction of hydrogen which is zero we all know that is that standard reference for us as the normal hydrogen electrode

so the reference normal hydrogen electrode we have and with respect to that we have the upper side that means the positive potential up to fluorine and the negative potential of to lithium

so that also covers the presence of iron presence of copper presence of zinc and all these

so we know that if we have iron nail we all know that the common day practice and common knowledge is that a iron nail if it is deep inside the corresponding copper like that of dipping magnesium inside the silver solution though if this is iron iron is just below this hydrogen electrode that is minus 0.

04 volt and copper is just above this particular value of plus 0.

34 volt

so this particular value is well matched for dipping this iron rod to copper solution a copper sulphate solution which is copper 2 plus

so this iron will go to this particular iron 3 plus and some amount of copper will be deposited on that iron 1 as copper and you get the corresponding nail as the red brown nail covered with a very thin layer of copper

so this is the typical driving thing typical driving force which is associated for their inherent electron transfer behavior because it is not a typical electrochemical cell what we are given by the electrochemical cell is form when the rod is dipped inside the solution of the same solution of that particular metal we get that but this particular observation always we get similarly if that particular copper rod is deep in the silver solution what will be the effect

so all these values are typically important and if we just little bit keep in our memory that what are the values for this and what is the typical trend we can have some good idea about the corresponding reducing agent and the oxidizing agent related to the corresponding zinc where zinc is there because there are metallurgical processes where not only zinc if we require more stronger reducing agent which is aluminium which is higher than that of our zinc

so we require aluminum for that particular reduction reaction in the metallurgical processes and sometime we also use magnesium for that particular extraction of the metal from its ore

so this this is the thing that we are still with that particular rust now we are moving slowly that particular rust to the corresponding mineral or ore

so this is not  $Fe_2O_3$  sorry this is  $Fe_2O_3$

so the reduction of this  $Fe_2O_3$  what we are seeing that how we get that

so this is the typical rusting process and this rusting process we get this we consider this as now as ore

so one of is  $Fe_2O_3$  another one can be  $Fe_3O_4$  that means the hematite and the magnetite

so these oxides are there or the hydrated hydroxides are there sometime little bit carbonates are also attached to there and this particular one how you go for this particular one that means the reduction reaction

so this is the reduction

so this reduction if we use that carbon we know that carbon is very good for the typical burning process or the combination reaction c is attaching with  $O_2$  giving rise to our  $CO_2$

so if this particular thing that means this o can come from this oxygen of this rust or the mineral that means the ore

so this can be reduced back to these iron metals

so this is a typical metallurgical process or the metallurgy

so this metallurgical process will involve the corresponding choice of the reduction

so carbon will be our reductant which can be utilized for the reduction of this iron from its ore

so iron we can produce in greater quantities than any other metal by reduction of  $\text{Fe}_2\text{O}_3$  this is  $\text{Fe}_2\text{O}_3$  with carbon or coke

so that is the typical methodology we use for getting iron from its ore

so carbon reduction is also feasible for other oxides say silicon we know that the silicon different silicates we know

so if we have silicates like iron oxide if we have phosphate as phosphate rocks manganese we also know that the manganese is present as  $\text{MnO}_2$  on the earth crust this is the manganese dioxide which is pyrolucyte

so that can also be reduced back to manganese metal by coke similarly tin oxide

so mostly all these oxides we are talking about the removal of this oxygen by the utilization of a very fascinating reaction of carbon which is coke and that is the corresponding combination reaction of carbon with oxygen

so this is the straight wave reaction

so if we just take the same rust whatever we are talking about we are standing there simply that we have the rust in our hand and rust is now our ore that means  $\text{Fe}_2\text{O}_3$  or  $\text{Fe}_3\text{O}_4$  the stoichiometry is only different

so which can be reduced by carbon giving rise to  $\text{Fe}$  and  $\text{CO}_2$

so a part of this reaction which is the formation of  $\text{C} + \text{O}_2$  we can consider it as the formation of the  $\text{C} + \text{O}_2$  as a typical example of combination

reaction in your books it is written as a example of a combination reaction

where  $\text{C}$  is attaching with  $\text{O}_2$  from the atmosphere or air or  $\text{O}$  from your  $\text{O}_3$  giving a typical combination reaction and these combination reactions are always very useful because carbon is getting oxidized

so we are talking something which is comes under the purview of redox redox chemistry

so  $\text{C}$  is getting oxidized to  $\text{CO}_2$

so what about some more examples

so magnesium we can use as the corresponding species for this combination reaction as we have seen that magnesium we can use the aluminum we can use

so if our  $\text{O}_2$  is there that means one reagent is our  $\text{O}_2$

so this is the reagent which can be utilized for converting this 1 this magnesium to its corresponding oxidized form that means  $\text{Al}_2\text{O}_3$   $\text{MgO}$  etcetera

so aluminium can be utilized like that of our carbon what we can use for getting iron in blast furnace

so aluminum can also be used for some reduction reaction of any oxide ore magnesium can also be utilized for this oxide reaction

so another category of this combination reaction is that if we have the metal itself and if we go the reaction not with oxygen but another more electronegative elemental form of fluorine gas

so what will form

so we know that the barium is the electro positive element and it is basically will be able to quickly remove the electrons from here and it can immediately give you the corresponding salt of barium fluoride like that of the thing what we have seen in our previous class as the formation of the corresponding salt of zinc as zinc chloride

so this is therefore the barium thing similarly this can also come for any organic compound

so if we just correlate these if we just think of all these things and what about the corresponding combination reaction of  $\text{C}_2\text{H}_4$  or  $\text{C}_6\text{H}_{12}\text{O}_6$

what we are talking all the time that the glucose oxidation reaction

so the products are very simple in these two cases always we have carbon dioxide and water because these are all made up of carbon and hydrogen carbon and hydrogen because these are all hydrocarbon type of thing or the sugar type of thing or the carbohydrates we have

so carbon will take its own share of this to give you the carbon dioxide similarly the hydrogen present in all these molecules will take its own share to give you the water molecules

so this is the typical reaction where we get this combination reaction what we find in case of this methodological process that this particular reaction if we just see that this particular reaction we have a corresponding free energy change that means the  $\Delta G$  value the thermodynamically quantitative value for this is that is that is  $\Delta G$  zero is a positive quantity

so is not a thermodynamically very much feasible reaction because we always know that the free energy change should be negative the reaction will go very fast is kinetically favorable as well as thermodynamically favorable but this particular case we see the reaction we follow the reaction at room temperature

so our room temperature is 25 degree centigrade and that room temperature is very useful to find out its corresponding  $\Delta G^\circ$  which is plus 151 kilo joule per mole

so the reaction is not at all a very good reaction if at all it goes on the right hand side because it is not thermodynamically feasible forget about its kinetic rate because the rate of the reaction how quickly how fast we get we generate this  $Fe$  from  $Fe_2O_3$

so what we do we just simply see that their temperature we just now control the corresponding temperature if we rise the temperature of this reaction

so the reaction will be more feasible and the contribution for this  $\Delta G^\circ$  we know that from that  $T$  will be coming temperature will be coming into the picture in relation to  $\Delta H$  and  $\Delta S$  and that particular  $T$  will now control to drive this reaction towards a favorable condition and we require a blast furnace which is not hundred is above thousand degree centigrade not hundred is above thousand degree centigrade

so basically we see that like iron

so for highly electro positive metals like that of calcium magnesium element the oxides are too stable in other case also where we get that this particular one that the electro positive metals like calcium magnesium aluminum

so  $\Delta G$  now is  $\Delta G^\circ$  is two negative

so this particular case also that this is negative and is also stable the required temperature would be also very high

so we get that in a different condition we can have and these different conditions can be for form for a particular reaction for this degradation from its corresponding oxides or a reaction which is getting from the use of that carbon from that particular reaction

so we can get therefore that this particular condition then oxides of calcium calcium oxide aluminum oxide or magnesium oxide from the metallurgical point of view what we see that this can be extracted in molten condition not in aqueous condition

so molten aqua molten alumina and then we follow the corresponding electron transfer not for any reducing agent but is from the electrodes

so the molten condition electrolysis will give the corresponding recovery of aluminium aluminium ion from alumina alumina is its ore

so  $Al_2O_3$  is its ore of alumina

so alumina can be recovered from its molten condition

so there also we require like blast furnace a high temperature because we

directly use this particular oxygen removal from our oxide ore

so this particular reaction we go for a particular case where we see that a typical decomposition reaction

so if we consider that these oxides

so  $\text{Fe}_2\text{O}_3$  is the reduction process then other things are the corresponding decomposition reaction one good example of decomposition reaction because if there is no change in corresponding oxidation states of the cationic part or the anionic part we simply see that when decomposition is taking place for calcium carbonate we get calcium oxide and carbon dioxide because this is a very good analytical technique also for getting estimation of calcium and its corresponding analytical values for presence of this calcium sample in any unknown material because we can have this and we can be obtained from calcium oxalate also because oxalate ions are very good ions which can bind nicely to these calcium centers

so that can be oxidized to this calcium oxide and carbon dioxide

so what about then this decomposition reaction because we use this particular sodium hydride in our previous class we are talking about something where we talk about that lithium aluminum hydride or sodium borohydride

so these are the species that means the thermal stability of these compounds are also important when you use for some transformation or reduction utilizing this where it can supply the hydride ions similarly the corresponding thermal stability of some compounds like boron the boron diborane compound  $\text{B}_2\text{H}_6$

so if that particular one is not thermally stable it can just simply go to the elemental boron and hydrogen gas itself similarly

so like that of you this is a t another boron hydrogen compound but these are all aluminium hydride and boron hydride compounds which we get the from there as a hydride on similarly sodium hydride

so this particular one where we have this as one plus sodium as the cationic form and this as the hydride

so  $\text{H}^+$  plus

so both of them can be moved to  $\text{Na}^0$  and  $\text{H}_2^0$

so this is the typical decomposition reaction what we can follow nicely for sodium hydride also and another interesting example of this is the corresponding decomposition of calcium chlorate because these are the compounds where we can have one or more chlorine oxygen bonds

so these are also very important in terms of the corresponding formation of this  $\text{Cl}_2$  with  $\text{O}_2$  in the chemistry of halogens or chemistry of these chlorides but what about the redox chemistry or the redox reactions related to the formation of this  $\text{ClO}$

so the thermal decomposition of this will be simply the formation of the most stable one that means the potassium chloride and removal of this oxygen sometimes it is also very much explosive in nature as this particular thing will remove some amount of oxygen directly from this particular chloride

so all these chlorates will be explosive in nature

so this particular decomposition reaction also is valid for simple ammonium chloride we all know that ammonium chloride with can form from the ammonia gas and hydrochloric acid or hydrochloric gas also  $\text{HCl}$  gas

so this can be decomposed also by two things that means your  $\text{NH}_3$  and  $\text{HCl}$

so this ammonium ion which is also a very important which has a typical level of oxidation which is minus three in an ammonium ion

so this ammonium ion if it is present along with nitrite or ammonium ion present with nitrate

so these are very important in terms of the corresponding presence of these nitrate and the nitrite ions which are oxidizing anions

so the presence of nitrate or nitrite ions are oxidizing in nature and the ammonium ion which can be oxidized nicely by the anion itself present over there in the salt

so there is no need to supply some anion or some oxidizing agent from outside so the thermal stability of these compounds are also very less

so they if we allow them to heat it

so they will be producing something where we get this nitrogen

so the nitrogen in this nitrite is in plus three this nitrogen of this nitrite ion and the nitrogen of this nitrate ion is plus five oxidation state

so plus three and plus five oxidation state along with the presence of this ammonium ion in minus three oxidation state

so that will be changed

so is the typical example what we have seen that you can have two oxidation states

so one is a minus or one is a plus

so similarly if it is nitrogen

so nitrogen which is there

so nitrogen in minus three and nitrogen in plus three

so this a or n

so this is nitrogen gas

so it is in zero

so always there is a tendency always will have some tendency for these all these reactions is the typical electron transfer reactions

so it will basically try to move to the lower oxidation state and this state will also try to move to the lower oxidation state

so the movement of these two species from plus three to minus three is the corresponding thing which is very interesting that if both of them are moving when this is minus 3 and plus 3 both of them are moving we get something where is we get we are getting this nitrogen

so  $N_2$  how we are in getting into

so you see that is interesting thing that nitrogen from this part and nitrogen from that part

so movement from this side and movement from that side will giving you  $N_2$  because we have to form a nitrogen nitrogen triple bond over there which was not present in this particular compound because we have large number of n o bonds and large number of n h bonds

so breaking of this n h and n o bonds are there by doing some very simple thermal reactions

so these are basically simple thermal reactions we can have some thermal analysis also

so thermogram we can have to know the temperature at which particular point it is giving rise to the release of this thing but this is a typical nature of this decomposition reaction of ammonium nitrate because ammonium nitrate where the nitrogen on the right hand side on the anion which is in the higher oxidation state of plus five it will not be allowed to go down to n two state but it will have some interesting molecule like nitrogen in the lower oxidation state of plus one

so this will be plus one of nitrous oxide with two molecules of water

so that is the thing that how we get this particular one

so when we go for the oxidation of this ammonium ion which is present

so some in some cases the decomposition reaction is such that the same ammonium ion in all these three examples what we see which is very interesting the presence of this anions what are these anions are these anions are c l minus this n o two minus and n o three minus how good they are because this

corresponding oxidizing ability or this oxidizing anions this oxidizing ability is increasing that's why we are getting these things that these different products that means ammonia we are getting in one case nitrogen we are getting another case in another case we are getting into O

so in a similar fashion if we can consider all other type of salts

so one such salt is ammonium dichromate the same philosophy we are considering we are considering that that ammonium is present and ammonium ion will be oxidized through this decomposition reaction and this thermally how good they are we have to just ignite it we have to hit it or you have to ignite it

so that dries giving rise to some chemical volcano we all know and this volcanic eruption for that particular reaction the transformation of this thing where we are going that means the same ammonium ion on all these cases we have the ammonium ions and those ammonia ions are present only we are changing from chloride to nitrite to nitrate to dichromate

so this dichromate will be there

so that particular dichromate decomposition also can take our reaction to the production of this N<sub>2</sub> and along with this particular N<sub>2</sub> we have Cr<sub>2</sub>O<sub>3</sub> and water molecules

so it resembles a volcanic eruption and producing basically sparks and large volume of green ash

so this is forming as the corresponding green ash

so this green ash is forming because some more amount of nitrogen gas is coming out from that particular ash

so very loosely formed ash will be there and the remaining thing what is there which is basically the hip of this particular ammonium dichromate

so we have this is particular for part is burning

so we have this particular greenhouse is there because and you have this porous thing is also definitely there because the nitrogen will be coming out from that particular species

so all these is about the corresponding decomposition reaction and in our next class we will just start with some displacement and disproportionation reaction and we will follow the remaining part of this class thank you very much you