

good morning everybody

so in this episode of chemistry class i will be talking about you on redox reactions this particular topic we will discuss because this redox reactions are mainly concerned with two things one is the reduction process and another is the oxidation process and studying this has serious implication on several aspects of activities particularly when we study from our early school days that the process which we know is the burning burning of say fossil fuels

so burning means in presence of oxygen

so what does it mean

so that particular type of burning we can consider that some material a is there which can be oxidized in presence of  $O_2$  giving rise to our  $AO_2$

so if our fossil fuel has carbon present in it

so carbon can be oxidized very nicely by forming its corresponding oxides and that releases some good amount of energy

so that is the requirement for the burning process but what about these two things that means the corresponding reduction process and the oxidation process because these two processes are starting from this burning of fossil fuel to another process which is the corrosion of metals

so most of these cases will find that they are very important in terms of the corresponding available metals whether it is a typical material where the metal is present as some iron rod iron pipe or something and we can talk about the environment where the environment can be correlated to the presence of this oxygen

so the corrosion of metals basically known as the corresponding degradation of the corresponding metal metal means it is in the metallic form it is in the zero state zero oxidation state

so typically what we see that in the case of this that means the burning of fossil fuel to the environment where corrosion of metal takes place we can have both these two processes of reduction as well as oxidation from very early days of photosynthesis we know another example and from my our early school days we know that is a typical process where plants do synthesize something for us involving carbon dioxide and water molecules

so this i will come later on where will find that how these two species can be useful for the formation of the glucose material which is  $C_6H_{12}O_6$  with the elimination of molecular oxygen

so in this process if we balance it also is the six molecules of  $CO_2$  and six molecules of water molecules will give rise to our  $C_6H_{12}O_6$  plus oxygen which is three in number

so in this process what we see that this is again a very simple process in terms of its oxidation and reduction where  $CO_2$  and water molecules are taking part actively to give us the corresponding  $C_6H_{12}O_6$  where the  $CO_2$  molecule is getting undergoing reduction and the water molecule is undergoing oxidation

so in this very simple process of photosynthesis what we know from our early days of schooling that there are also these two reactions that means the oxidation and reduction reactions are involved and this is involving formation of some energetic molecule because this particular thing that means the glucose molecule which can give rise to the carbohydrates which are our main source of energy

so there we find that this particular oxidation reduction reaction can take place which is not similar to that of our burning of fossil fuel or corrosion of metal ions or metals where addition of oxygen can take place

so if we come back over here where the addition of  $O_2$  to a giving rise to  $AO_2$  or  $AO_2$  type of thing

so anywhere the addition of this  $O_2$  to an element or compound if we can have

such as the species we can get is  $\text{Fe}_2\text{O}_3$   $\text{Fe}_3\text{O}_4$  or some other metal oxides like  $\text{TiO}_2$  titanium dioxide zinc oxide magnesium oxide

so these are the very simple example of this addition of this  $\text{O}_2$  or more to a metal where you have iron you have rhenium you have titanium you have zinc and you have magnesium

so these are basically sometime we will find afterwards that these are also the corresponding ores and minerals what we get on the earth crust

so the available metals as the metal ions is getting reduced to the corresponding metal and this undergoing some kind of addition reaction of oxygen for coming from the environment to give us the corresponding oxides

so addition of  $\text{O}_2$

so to these elements and compounds can be termed as the corresponding oxidation reaction

so what about this particular thing what we can find from the periodic table for this particular course is the class unit of one one zero eight

so and i am devastated talking about you to the redox reactions and this particular one can also be correlated to the rust in an iron oxide

so just now what i told you about the formation of  $\text{Fe}_2\text{O}_3$  is the corresponding iron oxide and this iron oxide can be formed from the combination of iron metal and  $\text{O}_2$  and what we have learned

so far that the addition of  $\text{O}_2$  to an element or compound or a metal is termed as the oxidation

so what type of this particular addition is that if we just go into the periodic table the whole periodic table if we little bit recall back that on the left hand side of the lower part we have the corresponding electro positive elements and on the upper right hand side we have the corresponding electronegative elements

so these are the corresponding electro positive elements and these are the corresponding electrode negative elements

so these reactions basically what we can consider that what is oxidation we can consider this oxidation therefore that  $\text{O}_2$  will be here somewhere here oxygen is here

so is an electronegative element

so addition of this electronegative element is also known as oxidation and reduction means the corresponding reduction means therefore the combination of less electronegative or removal of electrons

so here in case of oxidation we have the corresponding removal of electrons and here we have addition of electrons

so these two processes follow side by side where you find that in a particular redox reaction which is nothing but the reduction as well as oxidation process which involves both these processes and initially what we understand that fundamentally the redox reactions are a family of reactions where we consider about the corresponding transfer of electrons

so how do we know about the corresponding transfer of electrons

so the same oxidation process can be defined as the removal of electron loss of electron or another term we can use is increase in corresponding oxidation state

so here we see that the corresponding oxidation state of iron which is in the elemental state is metallic iron is in zero but in this particular case where you have the  $\text{Fe}_2\text{O}_3$  formation where the oxidation state of iron is plus three this iron is zero sorry this oxygen is zero

so this is both of these two are in the elemental state and has gone in this particular case to  $\text{O}_2$  minus

so increase in oxidation state that means the oxidation state is changing from iron zero to iron three plus that means f is 0 when it goes to  $\text{Fe}^{3+}$  plus is the

typical oxidation process and we see that the corresponding  $O_2$  is gaining electron and gain of electron and in a negative direction it is the decrease in oxidation state

so it is the corresponding decrease in oxidation state

so  $O$  is going to  $O_2$  minus which will be our reduction

so these two processes that means the oxidation and reduction reactions when occurred simultaneously that means in this particular case it is the loss of electron

so it is minus 3 electron

so loss is 3 electron and this is plus 2 electron giving  $O_2$  minus

so whenever we find that in a particular reaction there is a loss of electron obviously that electron can be taken up by some other species which will be responsible for its reduction by gaining of electron

so if we can go for some kind of burning of fuel as we are talking about

so some example is also that we can have the canon fire

so if we can have the burning of carbon which is the regular fuel for the typical burning process but if we get or if we use some oxidizing agent

so such as one typical well known oxidizing agent is our potassium permanganate so which can oxidize some other species where manganese is present in plus seven oxidation state and we all know that the manganese can have variable oxidation states from the elemental manganese which is zero

so this particular reaction is nothing but if we take  $KMnO_4$  powder and then we just sprinkle that powder on a burning mixture of  $H_2O_2$  which is hydrogen peroxide

so the reaction basically what we are thinking of in a different way for the typical fire if we consider that there is some firing or there is some a burning process

so what will happen therefore that means this particular species that means the  $KMnO_4$  will be available for its reduction reaction because the manganese is already in the plus seven oxidation state

so it will go down to plus four oxidation state in  $MnO_2$  and this hydrogen peroxide will be available for the production of  $O_2$  then we can have also water will be there from the reaction and the hydroxide ions

so in a single sort there is the evolution of this particular oxygen

so which is very much localized

so this localized evolution of  $O_2$  can accelerate the burning process burning process of art we are calling it as a canon fire and where this  $H_2O_2$  is there with some fuel material say we have taken this  $H_2O_2$  in ethanol  $C_2H_5OH$  or ethyl alcohol

so that ethyl alcohol will be burned therefore and the presence of this oxygen accelerates the corresponding burning of this  $C_2H_5OH$  and there is some burning process which will be responsible for this burning of this ethanol

so again we find that this particular one and we will just now carry on this one that how we get this  $O_2$  like that of our photosynthetic reaction where this  $O_2$  is coming from your  $H_2O_2$  or this water or hydroxide ions are coming from this  $H_2O_2$  hydrogen peroxide molecule that will see

so the rusting process what we are just seeing here that is rust is an iron oxide usually red and formed by the redox reaction of iron and oxygen in the presence of water or moisture and it consists of hydrated iron 3 oxide

so just now what i told you that is  $Fe_2O_3$  and if it is hydrated

so some number of water molecules will be attached to it and this will be red in color

so the formation of this starting from your iron and atmospheric oxygen simultaneously tells us that we can have the corresponding oxidation as well as

the corresponding reduction process

so if we have  $O_2$  which is a very important reaction that we all should know that  $O_2$  also we require for the burning process of our food material for our survival we also need  $O_2$  molecule for burning the food material what we consume for getting the energy

so in a typical reaction in terms of that electron transfer where four electron can be transferred to this  $O_2$  molecule and the presence of this water molecule is nothing but the source for the corresponding  $H^+$  plus to give you the corresponding hydroxide ions

so the hydroxide ions getting it from the  $O_2$  molecule is a typical reaction where we get a four electron reduction process and if we have more number of  $H^+$  plus proton over here

so we can produce more number of water molecules on the right hand side what does it mean therefore that  $O_2$  can be effectively reduced to water molecule

so that is the typical reduction process when we go for burning of the corresponding food material

so if we have the glucose molecule which is our  $C_6H_{12}O_6$  which is getting oxidized by  $O_2$

so  $O_2$  will take up these electrons to reduce it to either hydroxide ion or to water molecules

so this we have seen that at the initial stage this iron is initially oxidized to  $Fe^{2+}$  plus the oxidation process is the ferrous iron oxidation process with the removal of two electrons and this on further oxidation with this  $O_2$

so  $O_2$  is playing some double role or dual role this  $O_2$  is utilized to oxidize further this effector formed over there for the rust formation

so all these electron transfer reactions are pretty complex and particularly the very most important molecule is the water molecule

so what we know from our early days that the corresponding electron transfer reactions we do not study much for this water and  $O_2$  molecule and in immediately we just get the formation of the hydroxide ions and we can have the typical water molecule over there

so these always involve some transfer of electron

so if we consider that  $O_2$  is utilized for the reduction process

so it can take off electron

so  $O_2$  we all know that is a very standard bonding picture of  $O_2$  is a is a typical diatomic molecule

so if can it it can take one electron it can go to  $O_2^-$  minus

so that species we all know and if it again accepts another electron it will be  $O_2^{2-}$  minus which is nothing but the peroxide anion

so we will find that there will be a change in the corresponding bond order from a double bond nature or the character or between  $O-O$  it will be a single bond character in  $O_2^-$  and then again in single bond nature of full size is for the corresponding peroxide then if we find that there is some  $O-O$  bond cleavage the cleavage is there and this can give rise to the corresponding formation of  $H-O^-$  the hydroxide ion

so in this way the electron can be accepted by this  $O_2$  molecule and this  $O_2$  molecule will be responsible for the formation of your hydroxide ion but in this particular case in the third reaction where four  $Fe^{2+}$  plus plus  $O_2$  is forming four  $Fe^{3+}$  plus and two  $O^{2-}$  minus

so this will basically give us something where this oxygen is utilized for the oxidation of the ferrous ion to the ferric ion and this  $O_2$  is now converted to the oxide ion

so is another form of oxygen which is forming from the dioxygen molecule to produce the oxide ion which is present in water molecules say for a very simple

reaction

so if we just think this particular thing the one form of the periodic table where we see that this typical electronegativity values

so periodic table if we see in terms of the electronegativity values in powelling scale we find that in a case of this periodic table we have the cesium which is classified as a corresponding typical electro positive element

so this sodium potassium medium and cesium

so cesium will have a corresponding value of 0.

79

so in the periodic table the list electro negative element and the most electronegative element we can have

so this is cesium having a value of 0.

79 in the powelling electronegativity scale and the most electronegative one is the corresponding fluorine which is 3.

98

so this particular species

so this electro positive or the less electronegative element will be oxidized very easily and it can give rise to the corresponding electron transfer reaction and that electron transfer reaction can be supported by the presence of the corresponding most electronegative elements on the upper right hand side of the periodic table such as oxygen which is 3.

44 or the fluorine which is 3.

98

so in a particular case of this reaction see just now what we are seeing that the formation of hydrogen peroxide which is a covalent molecule

so the covalency of this particular molecule that means the hydrogen peroxide having o bond and h h bond what do you see that in the covalent bond formation we have only the partial charge transfer

so if we have partial charge transfer and if we see the difference in the electronegativity values between hydrogen and oxygen one is 2.

20 and another is 3.

44

so the partial charge generation on hydrogen and oxygen will be delta plus and delta minus by sharing of the electron pair between the bond of oxygen and hydrogen in a similar fashion the other bond the other o h bond will also have a delta plus charge and a delta minus charge on oxygen

so this is a situation where we can have the assignment for the corresponding oxidation state of this hydrogen and oxygen in this molecule compared to that of our water molecule

so water molecule is also a typical covalent one

so where we have this delta plus delta plus and the delta delta minus charge on this oxygen

so these are typical covalent molecules where we have only partial charge due to the difference in the electronegativity values of these two elements

so the electron pair which is holding these two atoms are shifted towards the oxygen side that's why a negative charge is being developed since hydrogen is losing its share for this electron pair a corresponding delta positive charge is developed on this hydrogen but from this particular situation this is due to the partial charge separation we cannot talk in terms of the corresponding oxidation state but here in this class we are only interested to assigning the oxidation state of these species these elements

so how we get this corresponding oxidation states of these elements or ah the corresponding hydrogen and oxygen is that we just consider that this particular charge separation continues and this particular charge separation is giving us

to something where we can have hypothetical ionic bond and that hypothetical ionic bond will lead us to a complete charge separation

so complete charge separation will give us something where  $\text{H-O-O-H}$  is there so it will be  $1 -$  this will be also  $1 -$  this is  $1 +$  and this is  $1 +$  plus

so in the hypothetical ionic bond formation whether it is for the hydrogen peroxide or the water molecule we will get that a complete charge separation can take place and this  $\text{H}$  which has already acquired a positive charge one unit positive charge can remove from here as  $\text{H} +$  the other hydrogen is also of same character

so it will also be lost from there by losing as  $\text{H} +$

so what we get we get the corresponding ion that means  $\text{O}_2^{2-}$  which we already seen here that due to the electron transfer

so complete electron transfer will also give us to this particular species which is  $\text{O}_2^{2-}$  with two  $\text{H} +$

so this assignment of this corresponding charges on the molecule which can be a covalent molecule but if we assume that a hypothetical electron transfer can take place where complete electron transfer can take place from the pair of electrons shared for this covalent bond to the most electronegative or the higher electronegative side we get this particular species

so this particular thing is the assignment only typically based on these periodic table based on the powelling scale

so if we take the another example that means this fluorine which is 3.98 and which is on the upper extreme side which is red in color also

so this fluorine

so this fluorine when it is forming some bond with one compound what we all know that which is  $\text{O}_2$

so how this particular charge separation can take place

so the difference between oxygen and fluorine is there which is 3.44 and 3.

98

so which is therefore the separation will give rise to a negative charge separation on  $\text{F}^-$

so  $\text{F}^-$  will always be there as a negative charge and this  $\text{O}$  will be  $\text{O}^{2+}$  plus

so though it is very unusual that we can have a oxygen center present in  $\text{O}_2$  molecule which has acquired a  $2+$  positive charge which is quite unusual but since it is attached to the fluorine atom and where the charge separation is of different nature and fluorine will attract the electron pair of this  $\text{O}$  a bond towards fluorine and it acquiring a negative charge

so  $\text{O}$  will be acquiring a  $\text{O}^{2+}$  plus

so that is why this acquiring of positive charge on this particular species are not unusual what we have seen that this  $\text{O}_2^{2-}$

so if we just know little bit about the corresponding molecular orbital picture of this diatomic  $\text{O}_2$  molecule we know that we can push one electron to the molecular orbitals and we can generate the species which is  $\text{O}_2^-$  which is our the corresponding superoxide anion

so superoxide anion can be formed

so this is our superoxide anion

so this superoxide anion is formed but the two electron transfer what we get from there is our this one which is forming as  $\text{O}_2^{2-}$  which is the corresponding peroxide ion but if our  $\text{O}_2$  is going for some kind of electron loss from the molecular orbital that means minus one electron

so like this of  $2-$  species it can also acquire some positive charge

so that will be  $O_2$  plus  
so this  $O_2$  plus which is the oxygen ion ion which can have some existence also  
so this  $O$  can therefore have different oxidation states  
so we can level for this  $O$  because if we consider that  $O$  is the standard element where the other compounds are forming by combination with the other elements like hydrogen like fluorine like  $Cl$  and all other  
so different oxidation states that means the possibilities of all these oxidation states are therefore important in assigning the particular oxidation state of oxygen as well as the other species or the other elements which is attached to this oxygen  
so based on this Pauling scale if we just consider that what we get the differences  
so Pauling scale electronegativity can tell us little bit about the corresponding chemical bonds  
so there is a error is  $Li$  in  $Li$  the  $Li$  fouling is  $Li$  in  $Li$  ok  
so there is the difference in electronegativity  
so if we consider that the species that means the bond is forming between  $A$  and  $B$  and  $A$  has a particular electronegativity from the scale and we just consider the corresponding difference  
so now the difference will tell us the corresponding nature of the corresponding bond what we have seen here also that when we have the covalent bonding in water molecule or hydrogen peroxide we consider that there is a charge separation a small amount of charge separation  
so the if the electronegativity difference is not much we get only the  $\delta^+$  and  $\delta^-$  charge separation  
so what we get we can tabulate this as in this particular table in this slide is telling us that you can have the non polar covalent bonding over here  
so this nature of this bond is therefore non polar  
so when this hydrogen peroxide or water molecule is present and it is not doing any other reaction basically that means some external agent is not added they remain as non polar covalent bond but if we consider that some reaction is taking place some  $A$  is reacting with water molecule itself then this particular non polar nature will not be there and that non polar nature will be destroyed and we can have the complete electron transfer giving rise to a corresponding polar covalent bond or ultimately release of this  $H$  as  $H^+$  which is a typical characteristic nature for the removal of this  $H$  as the corresponding ionic bond which we find in case of  $HCl$   $HCl$  we all know if we assign this is  $-1$  this is  $+1$  plus the oxidation state assignment but this is a typical gas molecule  
so this gas molecule has a covalent nature because this electron is shared by this one ardent paired electron on the chlorine atom giving rise to a covalent bond but when we dissolve it  
so if we have  $HCl$  over this  $HCl$  is  $A$  and it is reacting with water  
so this particular one will give rise to some reaction  
so where this reaction is giving rise to the corresponding removal of this  $Cl^-$  from  $HCl$  unit  
so this  $HCl$  which is gas which is dissolved in water and we get an aqua solution of  $HCl$   
so aqueous solution of  $HCl$  will give rise to  $Cl^-$  and it will be removed as  $H^+$   
so that  $H^+$  will be accepted by this water molecule giving rise to  $H_3O^+$   
so this typical nature what is originally present as a nonpolar or a slightly polar bond for this  $HCl$  when it is reacting with this water molecule is giving rise to a typical ionic type of bond which we find in case of sodium chloride  $NaCl$  because when sodium chloride is dissolved in water we know that it can

dissociate like  $n a^+$  and  $c l^-$

so the nature of this thing can be changed if we go from one particular reaction to the other like that of the difference

so if the difference is falling within the range of zero to 0.

5 we get a non polar covalent bond if it is 0.

6 to 1.

9 we get a polar covalent bond

so charge separation is applicable and if it is above 2 it will be a ionic bond

so if we consider that you have a sodium and chlorine

so the sodium chlorine separation will be above two and you have a typical ionic bond which is present in case of sodium chloride and assignment of the oxidation state is also clearly defined as  $n a^+$  as  $n a^+$  one plus and  $c l^-$  as  $c l^-$  one minus ok

so this particular type of bond

so dependence of bond type is basically governed by two parameters means we are talking in terms of the electronegativity

so the electronegativity difference is there and the average electronegativity

so if these two parameters are the controlling parameters then we can define this particular nature of these molecules as whether it is ionic compound or a covalent compound

so in case of this ionic character like which is present in  $nacl$  is governed by the partial charges of the bonded atoms and this particular character is there if we have a typical change but another character we consider here also is the metallic character that means if we have both of them as sodium

so if we have sodium and side by another sodium is also there that means the metallic sodium

so there again you do not have much difference in the corresponding electronegativity

so we get something but which is not of the type which we get in case of  $cl_2$  or  $h_2$  the hydrogen molecule or the chlorine molecule but here this typical metallic character will be governed by highest occupied molecular orbitals

so we have to take the help of the molecular orbital picture of these and the gap between highest occupied molecular orbital and lowest unoccupied molecular orbital will give rise to the band gap and that band gap will tell you some metallic character

so conduction band to valence bands are formed and those bands will typically go for a metallic bond

so is of different type and we basically see that the nature of the dependence allow the rationalization of the variation of the bond type

so we see how these different bonds are basically forming when we just allow the corresponding formation of the different types of molecules

so we see some of these examples

so is basically a triangle a ternary plot and this triangle basically is nothing but examples of some binary compounds or ternary compounds like

magnesium hydride or lithium hydride where we consider that where we get

so you have this particular one that means the difference as well as the average electronegativity values

so these electronegativities values we typically dictate us where we have this  $f_2$   $h_2$  and  $cl_2$  where this difference in electronegativity the  $\Delta$  values on electronegativities are 0 but the corresponding average electronegativity is high which is in the range of 2.

5

so that's why this  $f_2$  and all other species are close to the covalent nature and this particular covalent nature is also valid for our  $o_2$  molecule and your

br<sub>2</sub> molecule also

so if we go along this line we see that just now we have seen that this species like of<sub>2</sub>

so similarly other binary species are also forming and we get that is water is there which is in between

so you have some covalent nature of this water molecule but you have something where some charge separation is there and that charge separation is basically giving us some example where we get that partial charge separation will bring this because your average value is little bit high which is in the range of 2.2 or 2 in the range of 2 but the difference is small

so you have some charge

so as we move from this line from this covalent to the ionic side will find that the nature of these molecules are changing as we move from f<sub>2</sub> to csf the cesium fluoride which we all know that the typical ionic compound

so this cesium fluoride will be there which is very much similar to that of our sodium chloride

so what we are changing we are changing the presence of the other elements

so other elements as we change we move from there to the other side

so assigning this from the difference in corresponding electronegativity values are sometimes very straightforward but if we find that is not always

so simple if we get some species where we can have the species like this brf and clf

so this particular thing that means one more example is our clf and one is brcl

so if we look at the corresponding values for electronegativity we will find because already we have seen side by side that how you just consider the hcl or hbr

so this will be 1 plus this will be 1 minus similarly for hbr also it is 1 plus and 1 minus but what about this

so in this particular case

so is clf

so this will be 1 plus

so is not one minus because you have electronegativity difference from fluorine so fluorine will acquire the one minus charge

so these are the typical inter halogen compounds this inter halogen compounds will tell us the corresponding charge separation as well as the assigning of the oxidation state on fluorine on chlorine similarly for brcl also the beer will be one plus and cl will be one minus

so that assignment we always should keep in mind the corresponding delta values of all these things for assigning the corresponding oxidation states

so this particular bond also we see that these are typical corresponding inter metallic species

so inter metallic species are all metallic in character and in case of metallic thing that we since we do not have any separation the electronegativity separation is not much

so we will not find any charge separation or are localized in the different bands what we see for the corresponding conduction band and the valence band

so what we see that in the case of water oxidation just now we have seen that water is getting oxidized for the formation of corresponding o<sub>2</sub> molecule and that particular o<sub>2</sub> molecule is our corresponding oxidation reaction

so at the same time if water is getting that particular electron through the oxidation of water for the production of this o<sub>2</sub> what we get for the photosynthesis also that something should be present over there which can consume these electrons which is produced in the first step for the oxidation

so this can be consumed by the corresponding protons or  $H^+$  or the hydrogen ion forming the hydrogen gas or the hydrogen molecule itself through reduction process

so overall the reaction is nothing but for the water oxidation reaction we must have the production of hydrogen and we must have the corresponding  $O_2$  also

so this we also consider also called as the water splitting reaction

so that particular water splitting reaction is another reaction where we get this  $O_2$  that means the production of  $O_2$  for the photosynthesis but in case of photosynthesis hydrogen production is not there because this hydrogen the corresponding reduction equivalent is consumed by the  $CO_2$  molecule and that  $CO_2$  molecule will be responsible for the production of glucose

so this particular process what we see there which is a natural process and we also considered is as a photosystem two and it is provided by the plants

so this particular reaction is providing us protons

so these protons are forming and the electrons for the photosynthesis process and release oxygen to the atmosphere that's why we get the release of oxygen

so the very basic reaction for our survival for the photosystem 2 or the  $PS_2$  what we consider is that there is a typical oxidation reaction what nature does for us

so in this particular class of this redox reaction what we see that we can have some material and that have the ability to oxidize the other substance and is said to be oxidative that means it can oxidize the other thing

so it is oxidizing agent or oxidant or oxidizer

so what does it do it does basically it removes electrons from the other system or the other substance

so when it gets electron then that oxidant will be reduced itself

so thus it itself is reduced

so if we get some example of oxidants

so you should also characteristically know because in our next class we will see that if we get some species like say  $MnO_4^-$  that means it is the anion which is derived from potassium permanganate which is  $KMnO_4$  or some other species the metallic species are the metal oxides like osmium tetroxide where we what we have we have this typically we can assign the corresponding oxidation states that  $Mn$  has the chromium has here also the chromium has and also that is typical osmium has

so in all these cases what we see that if we have osmium tetroxide we all know that osmium is present in the iron group

so iron then we have ruthenium then we have osmium

so it is possible that you have this a tetroxide is there and side by side we have also  $CrO_3$

so if we assign these are oxides

so these oxides are there

so quickly we can assign the oxidation states for these oxides as  $O_2^-$  minus

so obviously the chromium will have a hexavalent and osmium is also 8 plus

so these oxidation states what we reach there starting from chromium 0 or osmium 0 is not

so easy because by the loss of six electrons over here and eight electrons over here will take us from osmium zero to osmium tetroxide similarly from chromium zero to chromium trioxide

so these are the species which have high oxidation states

so what does it mean basically because this is the highest possible oxidation state of chromium this is also the highest possible oxidation state of osmium and we do not have any electron on chromium and any electron on osmium

so we are not able to go beyond this oxidation state

so the other thing it can do it can very easily accept electrons  
so it can accept electrons  
so plus electron  
so it can function as a good oxidant and itself is reduced and go down to the lower oxidation state similarly  
so species having high oxidation states and other species what we are just now discussing in terms of the electronegativity values your  $O_2$  your  $F_2$  your  $Cl_2$  and  $Br_2$   
so that can gain extra electrons  
so these are also oxidizing agents or oxidants how because these can also accept electron already we have seen just now that  $O_2$  can accept electron it can accept two electrons giving rise to  $O^{2-}$  or it can break two hydroxide ion or the water molecule similarly fluorine chlorine and bromine can also accept electron to move to fluoride to chloride to bromide  
so electronegativity will tell us that this can easily accept electron and they are also good oxidants because they are easily reduced  
so we find that in this particular case that the reverse one the other process which is the opposite of these oxidants  
so these are all reductants  
so reductants are what reductants are basically therefore very easy to see from the periodic table on the left hand side or the left hand lower side of the periodic table that the if we have the electro positive metals like lithium sodium magnesium iron zinc and aluminium that can donate electrons easily  
so if we know that these some of these metals these are responsible for some reaction which are violent in nature because we know that sodium can be violent if it reacts with water because it immediately gives rise to the corresponding burning process of this water and it can immediately go for the corresponding reduction reaction and it gives rise to the corresponding electrons to the other species  
so can donate electrons readily  
so if we just think of the corresponding zinc also and zinc in the elemental state or the metallic state we can consider at the zinc is a typical species and direct reaction we can have  
so the laboratory example of this particular reaction this iodine we all know that iodine is a solid one also black particles iodine solid  
so if we consider in terms of the corresponding redox reactions between zinc and iron we see that this particular zinc is the reductant  
so it will basically give rise to electrons  
so the electron flow will be taking place from zinc to iodine and directly there we basically go for a corresponding salt  
so the is a typical example of synthesis of metal salt of a typical metal salt which is zinc and which is by valencing presence of bivalent zinc  
so the zinc two salt is directly forming and if we add this zinc powder to a solution of these in ethanol because if you have to dissolve this one and we get some exothermic reactions  
so the reaction is exothermic  
so heat will be liberated by producing zinc iodide in the reaction and since it is in the ethanol medium  
so this will be in solution  
so this particular thing in ethanol solution and this ethanol solution if we go for evaporation  
so evaporation will give rise to some white powder  
so we get a typical metal salt from the direct reaction of zinc and iodine and is a typical example of the corresponding redox reaction

so that is why the zinc whether it is present in the powder form whether it is a zinc granules or zinc rod because this is a specific species in different electrochemical cells also in the battery also because zinc has the corresponding tendency to be oxidized that means it can provide us free electrons similarly what are the other species will encounter not only the metallic but the hydrides transfer reagents that will talk next that the hydride transfer reagents such as sodium borohydride or lithium aluminium hydride which we use very much in organic chemistry that basically provide not only hydrogen gas but  $\text{H}^-$  which is the hydride ion

so hydride ion will transfer those electrons very easily to some organic molecules similarly this hydride ions from this species is also very useful

so hydrides are also very good reductants and also industrially important some species which is the hydrogen gas itself

so hydrogen gas we always require because the gas is the reducing agent

so gas will give us the required electron for the reduction reaction and that gas will give rise to the corresponding electron to the system in presence of some species which are considered as the catalyst that means the activation of this  $\text{H}_2$  is required because hydrogen molecule we know that it has  $\text{H-H}$  bond

so activating this  $\text{H}_2$  by using palladium platinum and nickel catalyst will be useful and that hydrogen atoms the activated hydrogen atoms will transfer for the whether it is a reduction for organic chemistry or it is the reduction for the electron transfer reaction

so this particular thing we will just see that what we have seen in terms of the corrosion that means the corrosion is the corresponding electrochemical oxidation that if we have something whether you have iron in your system or the iron pipe or you have zinc somewhere that metallic zinc is present

so will definitely get corrosion because it is degrading and it is forming zinc ion or the iron ions because the oxidant oxygen is present in the environment

so in case of iron or the corresponding degradation of zinc or any other metal is the corresponding rust

so which is common name for the formation of iron oxides and is a typical example of a typical electrochemical corrosion

so presence of oxygen and moisture will generally set an environmentally available electrochemical cell and that electrochemical cell will be responsible for electron transfer reaction

so all these reactions basically what we get for the formation of this  $\text{Fe}_2\text{O}_3$  and by some chemical or electrochemical reaction

so corrosion is a natural process what we see and it converts a refined metal to a more chemically stable form such as oxides what we get as the corresponding ore or minerals or sometimes sulphides also can help and the gradual destruction of these materials by this process by environment that means the presence of water and oxygen molecule will give us a typical example of a redox reaction ok thank you