Novel Separation Processes

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Module No. # 01
Lecture No. # 01
Fundamentals of Separation Processes

Good morning, everyone; so we will be starting the our cover course novel separation process and will be this is; the first lecture as, I told you earlier that these this lecture; will be on the fundamentals, of the separation processes and broadly; we will look into the driving forces separation processes and the kind types of separation processes in general and we identify; the novel separation. The separation processes, which can be categorized as novel separation processes, and later; on we just take one by one various separation processes and do the detail study. So, basically; separation processes are integral part of any process flow sheet.

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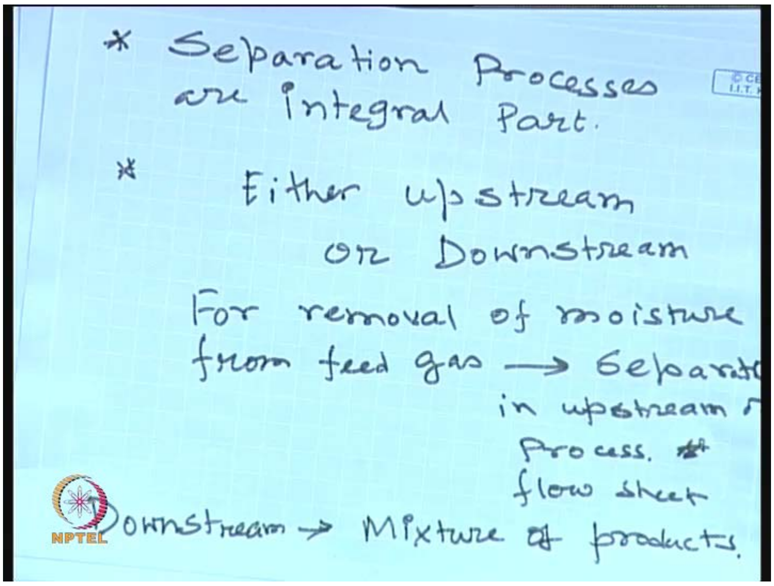

* Separation Processes are integral Part.

* Either upstream or Downstream

For removal of moisture from feed gas → Separat in upstream Process. flow sheet

Downstream → Mixture of products.

So, any separation any detail process flow sheet, of any industrial process separation processes, are integral part. Now, they can either put in downstream or upstream units Either upstream or Downstream that means; in any if, you talk about a reactive system some about reaction, is going on let us, say we carry out some reaction and they are some products and now, in this process the reactive becomes, the heart of the system.

Now, suppose in the in this reactive system. We are we are using a gas, which may be relating with the moisture and we like to separate the moisture and moisture free gas will be a feed to the reactor. So, in this case, we have to have separator unit need the upstream of the system to remove, the moisture for removal, this example, only removal of moisture from feed gas. One has to put a separator or separation unit, in upstream of process flow sheet that, means the separator should come first followed by the reactor and then, the other processes. Now, another example; where the downstream separation processes will occur the downstream in the downstream, of the process. We put the separator is the suppose; we have a mixture of products, now in this case and you are identify to take out one particular, product from the mixture; of 3 to 3 to 4 products. Then you have to put a separator, in the downstream of the process flow sheet.

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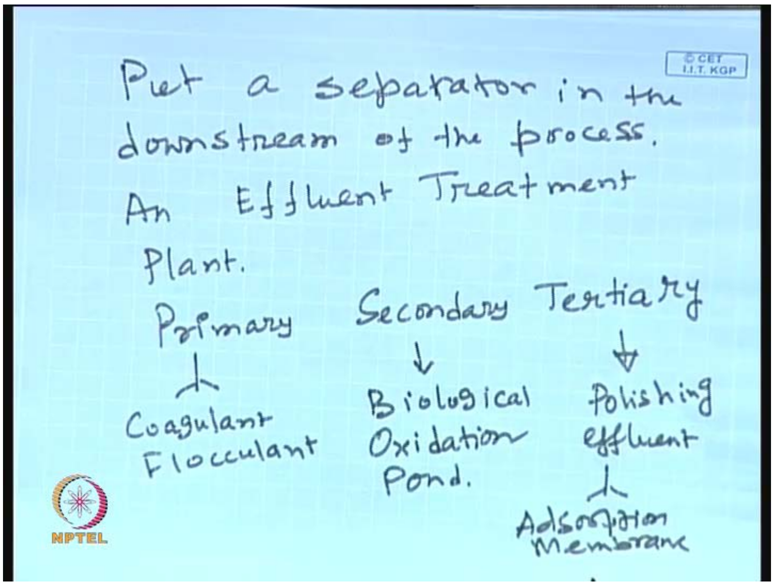

Put a separator in the downstream of the process.

An Effluent Treatment Plant.

Primary → Coagulant Flocculant

Secondary → Biological Oxidation Pond.

Tertiary → Polishing effluent → Adsorption Membrane

So, in this case; the you have to put a separator in the downstream of the process. Now, if you talk about; a and a effluent treatment plant, and a effluent treatment plant separator are the separation process or separator, unit is the heart, of the plant. So, there are several types of separation that one can think of in an effluent treatment plant Primary Secondary and Tertiary in the primary. You use coagulation coagulant flocculants; So, What is the difference between the coagulant and flocculants?

In coagulant you use some material for example, ferric chloride or you know potash alum or calcium oxide depending on the p H of the effluent add some coagulant. What this coagulant will do this coagulant are basically; charged colloids, and they will attract the solute of opposite polarity; and they will form heavier material mean means, heavier (( )) rate and that, will deposit at the bottom of the tank.

So, that is the coagulant and what is flocculent flocculants will be almost same thing, but it will be floating in the liquid. So, flocculent (( )) material has to be taken; out from the top of the material reactor; and the coagulant the and after coagulation. The total solutes will be taken, from the bottom that is, the difference between the coagulation and flocculation these are basically; the primary separator separation process, in any effluent treatment plant. Now, if, you go for the secondary units after this primary treatment one has to go for the secondary unit here basically; biological processes, will be taken into place will be will be taking into place for example, Biological Oxidation pond.

Where there is a huge pond there, put the material and the effluent and the oxygen will be supplied in the different. You know mechanical arrangements; for example, you may be having porous pipe like the here has been flooring and the oxygen will be taken out always in the form of the bubbles. So, there will be a rapid mixing and forth so, biological oxygen biological degradation will occur in that and after that the clarified liquid go to the tertiary unit. So, there will be a biological oxidation pond in case of secondary treatment in case of tertiary treatment.

You are its they are called polished polishing steps, so you are basically; polishing the effluent and removing the trace amount of solutes solids, those are still, they are in the effluent by various processes like, Adsorption membrane separation so, and forth there are three distinct separators, separation processes; those will be occurring, in a typical effluent treatment; plant primary secondary and tertiary and basically; in an effluent treatment plant. If, all the processor processes are nothing, but the separation processes.

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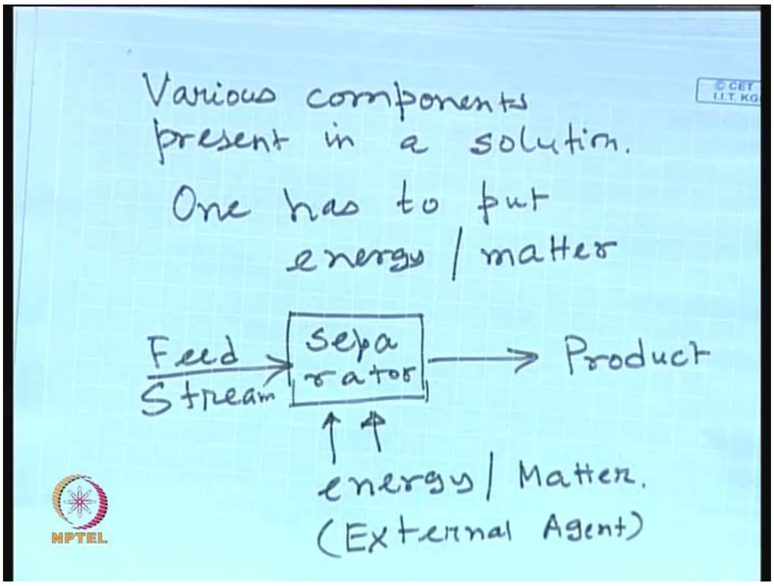

Various components
present in a solution.
One has to put
energy / matter

Then suppose you like to separate the various components; present, in a mixture present in a mixture or a solution for example, a salt solution it is typically, a solution right or there is a mixture of various components. Which are naturally, occurring, now what do you would like to do you would like to separate out these components, from the natural naturally occurring material substance. What is the substance; it is the mixture. So, you must be putting something from outside some external agent into the system that will cause separation of the individual units or individual components.

What that can be that, can be a material or that can be an energy. So, one has to put either energy or matter or material to affect separation for example, if this is the this is, the separator unit and this is the feed stream. This is, the product stream then there must be some unit in input to the system in the form of either energy or matter. So, this is the basic flow sheet of any separation process; and I will give some examples for example, if you talk about distillation; what is the external agent. So, this is basically; the External Agent; that will affect that, will affect separation.

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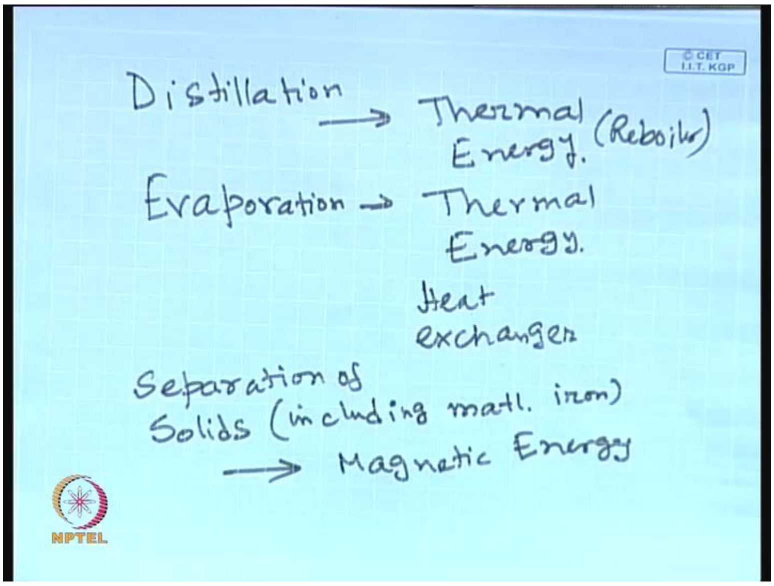

Distillation → Thermal Energy. (Reboiler)

Evaporation → Thermal Energy.

Heat exchanger

Separation of Solids (including matl. iron) → Magnetic Energy

Now, for example, distillation incase of distillation. We gives Thermal Energy; how we are giving thermal energy; in the form of re boiler. So, re boiler is basically; the source of that provides thermal energy, for the separation; in the distillation in case of Evaporation again; it is not a matter, it is a Thermal Energy, it is energy in the form of thermal energy that, will be leading to separation of gas from the liquid vapor from, the liquid and what is the you know unit, that will be giving, the thermal energy; in this case. It is Heat Exchanger right, and in case of distillation. It is Reboiler separation, another example, is separation of solids, including a magnetic material like, Irun iron if, that is, the case then magnetic energy, can be can be utilize for separation of Irun iron from mixture of various solids. Now, these are the various you know examples, of the external agent is energy.

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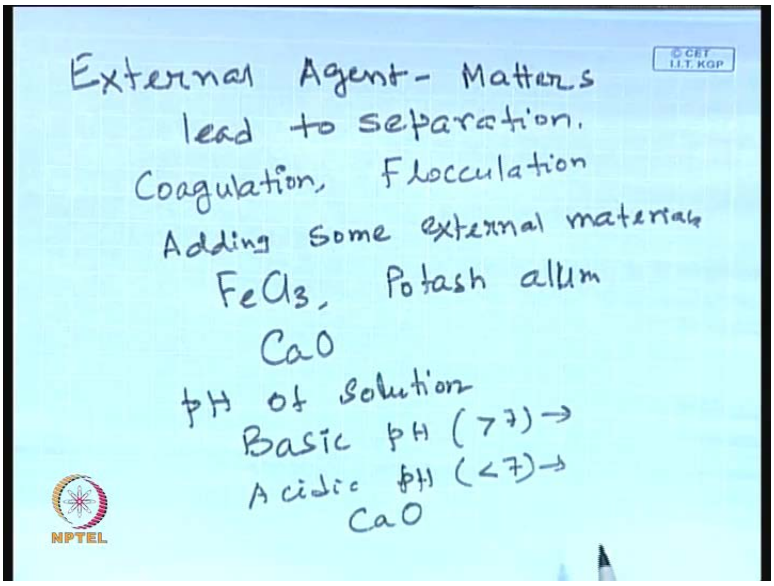

External Agent - Matters
lead to separation.
Coagulation, Flocculation
Adding some external materials
$FeCl_3$, Potash allum
CaO
pH of solution
Basic pH (>7) →
Acidic pH (<7) →
CaO

Now, I will give you some the example where the External Agent is Matters that, will lead to separation for example, coagulates Coagulation Flocculation. You are Adding some external materials; to the system like FeCl3 a is coagulant potash alum CaO of various doses now, you know these are various an external materials that, will be matter that will be added into the system to affect coagulation flocculation. So, and forth there are some flocculating; agents, are there which will be causing flocculation. Now, just for a diversion; I would like to say that which type of coagulant. You will select to affect separation.

Now, weather will be using ferric chloride or weather will be using calcium oxide or weather you will be using a potash alum that will be typically; depending on the p H of the solution that you are going to treat. So, p H of the solution is becomes is very vital when that will dictate the type of material type of coagulant that we are going to use for example, if you have an Basic p H that is p H greater than 7 then obviously, the choice will be ferric chloride or potash alum. Which are basically; acidic in nature? So, that the final p H of the treated effluent will be close to normal, p H which is around 7 similarly, if you have some acidic p H it is less than 7 example of a basic; p H is a textile effluent (( )). Which will be having p H in the order of around 10 to 12? It will be having very high basic p H, because of presence of sodium hydroxide, and other materials present in the system on the other hand if, you talk about a pickling effluent in a tertiary plant pickling is a basically; a treatment process a unit processing in a tertinary. Where there lots of acid is you know added to the system; and the effluent that is generated out of these unit is known as the pickling effluent and it is highly, acidic in this case the a coagulants like FeCl3 or potash alum will not do with that case coagulant, like calcium oxide will be good. So, in the in the case of acidic p H you can use CaO.

So, that it will be it will be basic in nature and the final p H of the solution will come to close to neutral p H when it is always good to have a have an effluent at neutral p H suppose, you are having an effluent after treatment; which will having a p H in acidic range or in the basic range that, will be very dangerous if, you discharging in the surface water or in the river stream. So, for that you have to another unit operation that is for p H adjustment. So, there you have to either alkali or in a base depending upon the situation to bring the p H of the solution; to the normal p H that particular; step is called neutralization.

So, you must be having another step call, neutralized another unit operation is called a neutralization. At the end step after if, the solution becomes highly basic or acidic; so, it is better to have a coagulant or flocculants, which will lead to a solution which will be close to normal p H.

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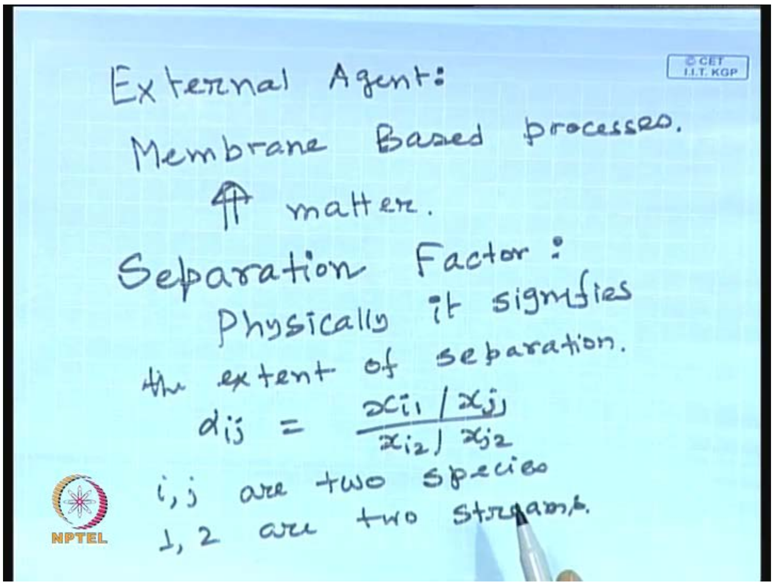

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External Agent:

Membrane Based processes.

↑ matter.

Separation Factor:

Physically it signifies the extent of separation.

$$\alpha_{ij} = \frac{x_{i1}/x_{j1}}{x_{i2}/x_{j2}}$$

i, j are two species

1, 2 are two streams.

Another example of External Agent has matters is membrane Based processes the separation processes. What is this membrane? Is basically; a phase that will dictate the basically the relative you know different magnitude of transport rate of various species.

So, depend because of the various you know difference in the rate of transport of various spices one spices will be preferentially; transport to the other side. So, the downstream of the membrane will concentrate in one particular species and upstream; will concentration of particular spices, that is,

Why the separation will be occurring due in the presence of the membrane will be going in the detail of the this the membrane in separation processes therefore, the external agent is again; a material; a matter called membrane. This is, an example of External Agent being an material, we have examples; of you know separation, or the External Agent is energy in the form of thermal energy magnetic energy. So, and forth next we define a factor called Separation; Factor physically; it signifies the extent of separation. What is the extent of separation? 30 percent separation forty percent separation ninety percent separation. So, it is defined by a quantity called alpha i j. Which is defined as, x i 1 divide by x j 1 divided by x i 2 divided by x j 2 here, i and j are 2 species and 1 And 2 are two streams. So, basically; we are talking about two species to be separated from two streams. Now, it one can it will be basically; the this gives the relative unit that that means 1 stream is concentrated; more in a particular species compare to the other stream. So, it cannot be absolute; it will be always relative; so if, I talk about the between 2 streams,1 streams ,number two is concentrated in species I that means amount of the species; I is more in the particular stream compare to the other stream. So, it is basically; always comparative.

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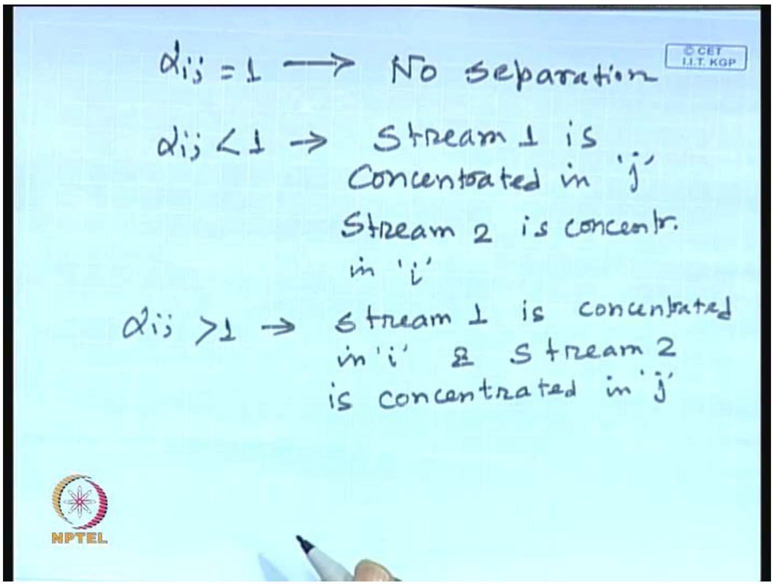

$\alpha_{ij} = 1 \longrightarrow$ No separation

$\alpha_{ij} < 1 \rightarrow$ Stream 1 is Concentoated in 'j' Stream 2 is concentr. in 'i'

$\alpha_{ij} > 1 \rightarrow$ stream 1 is concentrated in 'i' & stream 2 is concentrated in 'j'

Now, if, alpha i j is equal to 1, that, that simply; indicates no separation. There is no separation between the salt and the salt and water in a (( )) solution and alpha i j less than 1, indicates stream 1 is concentrated in j in component j, and stream 2 is concentrated in species i an alpha i j greater than 1 indicates that stream1 is concentrate in i and stream 2 is concentrated in j. So, one it is like it is more or less like relative (( )) type of definition incase of distillation. If, you remember so, depending on the concentrations of various species present in various streams 1 can identify the value of separation factor and looking into the value of separation factor weather. It is weather it is fraction weather; it is greater than 1 can come to conclusion. Which stream will be concentration will be more, concentration; in particular species. Which stream is less concentration with respect to the particular species?

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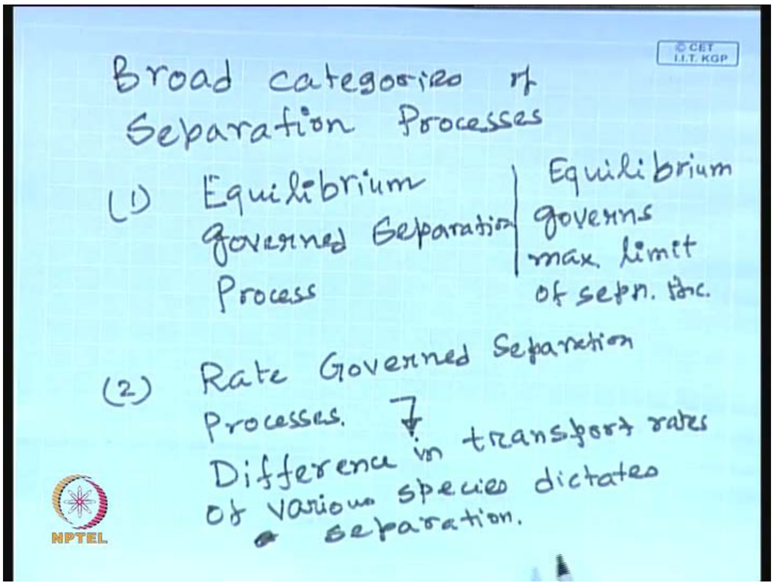

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Broad categories of
Separation Processes

(1) Equilibrium Governed Separation Process | Equilibrium governs max. limit of sepn. fac.

(2) Rate Governed Separation Processes. → Difference in transport rates of various species dictates separation.

Now, broadly; there are two categories of any separation processes broad categories. Now, let us, try to identify the broad classifications of separation processes, what are these broad categories? 1 is equilibrium governed separation process; another is Rate Governed separation processes. So, there are two, broad categories of separation processes 1 is equilibrium governed separation processes, and the another is Rate Governed separation processes, what is the equilibrium governed separation processes? In this case, the product streams are in equilibrium, with the inlet streams, that means once the equilibrium is raised the product cannot be more concentrate, compare to the equilibrium concentration that means; if, you remember the equilibrium diagram of the various mixture.

So, equilibrium will dictate the maximum limit of separation in this cases, Now, the conventional separation processes those you have already; studied in the unit of portion of chemical engineering in a courses for example, distillation absorption adsorption drying etc. All are fall under the equilibrium Governed separation processes. So, equilibrium there is a particular equilibrium of the of a particular species in two phases in vapor phase or liquid phase or two streams that, will dictate the maximum limit of the separation process equilibrium, Governs maximum limit of separation on the other hand the Rate Governed separation processes are basically; the difference in transport rate of various species dictates separation difference of transporters.

Where in the separation medium for example, most of the membrane the separation processes are Rate governed separation processes, suppose; you would like to separate a saline salt out of water using a reverse osmosis membrane. So, in that case the transport of the salt through the membrane will be extremely; small compare to the transport of Rate of transport of solvent. So, that is, water through the membrane, because water molecules are much small in size therefore, in the downstream unit downstream side or in the permit side the concentration of salt, will be very less compare to the upstream of the feed side.

So, that that will transport of this two particular species through the separating medium will dictate the amount of extent of separation. So, in the permit stream or downstream will be dilute as for as the salt is, concern and the other hand the upstream; will be other feed side will be more concentration, in case of you know compare to with respect to salt. Now, we just talk about various, separation processes, and the characterization starting from, equilibrium separation processes.

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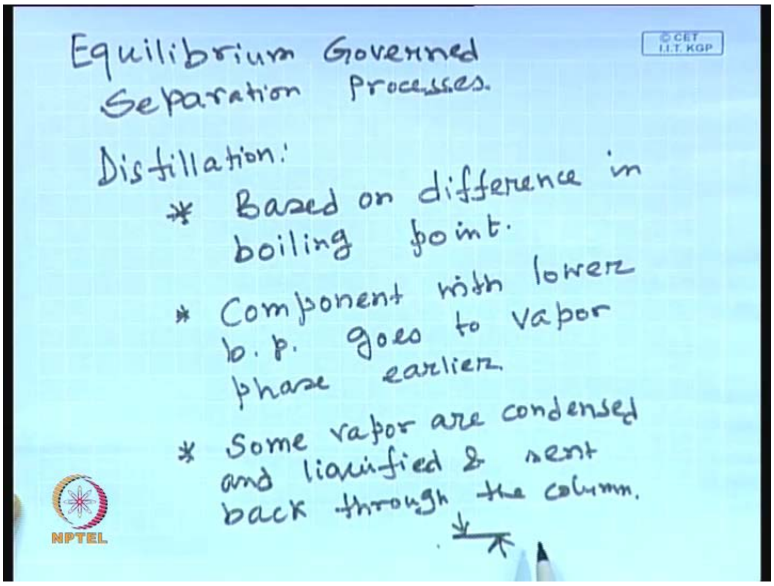

Equilibrium Governed
Separation Processes.

Distillation:

* Based on difference in boiling point.
* Component with lower b.p. goes to vapor phase earlier.
* Some vapor are condensed and liquified & sent back through the column.

Let us, look into the a equilibrium Governed separation processes and some of the examples and their characteristics for example, Distillation the first characteristics, is it is based on difference in boiling point. So, difference in the boiling point of the species, will dictate the Distillation Operation. The extent of separation during Distillation component, with lower boiling point goes to vapor phase earlier there is quite obvious. Now, the third characteristic is that some vapor which will be coming out from the top of the column are condensed.

They are liquefied and sent back through the column; what it does therefore, there will be a counter current operation the liquid is, coming from the top and the vapor is going from the bottom during this counter operation. There will be tremendous there will be very good mixing of the liquid and the vapor and, the one particular; species may be transfer more into the vapor phase. Which will having the lower boiling point, So, there will be a good conduct there will be more process, but these transfer. If, this transfers; if you talk about various, you know in fact in a liquid there is various stages. Now, if you talk about a particular; stage the liquid is coming; from the top the vapor is going from the bottom and the composition is always in the equilibrium that is, the maximum possible separation; one can achieve, so one we talking about the you know the equilibrium composition exists between the inlet and outlet it is not the overall. The total column it will be on differential small stages, inside the column. So, at every location the equilibrium, will exist between the incoming and the outgoing streams; that will dictate the extent of separation; in a distillation column

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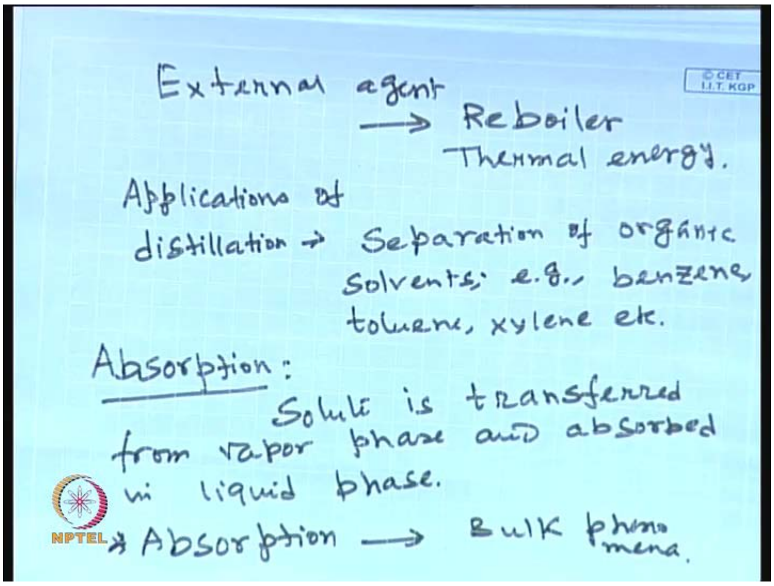

External agent
→ Reboiler
Thermal energy.

Applications of distillation → Separation of organic solvents; e.g., benzene toluene, xylene etc.

Absorption:

Solute is transferred from vapor phase and absorbed in liquid phase.

→ Absorption → Bulk phenomena.

Now, the Distillation Column the External Agent, we have discussed earlier is re boiler the External Agent is re boiler Reboiler is basically; the equipment that will be supplying thermal energy for separation, let us, look into some of the applications of distillation the applications are separation of organic solvents for example, you know benzene toluene Xylene etc. An the there are other applications of distillation, also depending on the boiling point, and how the boiling points, are weather the boiling points are close, or they are far apart depending; that will be depending on the situation and depending on that you know extent of separation, or the efficiency of the process will be dictated another process is absorption. I think these are very common to the chemical engineering student but since, there are lots of student from the other departments. I would like to just give a small introduction on various processes those will be occurring in the end of the in a categories of equilibrium Govern separation processes and Rate Govern separation processes.

I will be coming, after that absorption is basically; solute is transferred from vapor phase and absorbed in liquid phase suppose; you are there is a there is a solute there is present in vapor form and you would like to preferentially, extract on that particular; solute in some medium the medium may be a liquid phase. Where the solute concentration; will be absolutely low. So, there will be a typical concentration gradient that will be existing of the solute between the vapor phase and liquid phase, and the solute will be coming to the vapor phase and it will be in the liquid phase; and it will be dissolve their, it is called Absorption and since, this is, occurring throughout, the whole, Bulk of the solution Absorption is a Bulk Phenomenon there is a first characteristic Absorption is a Bulk Phenomenon the solute, that you are going to get in the liquid phase; there are several methods; to get out of the liquid and you know recover solutes.

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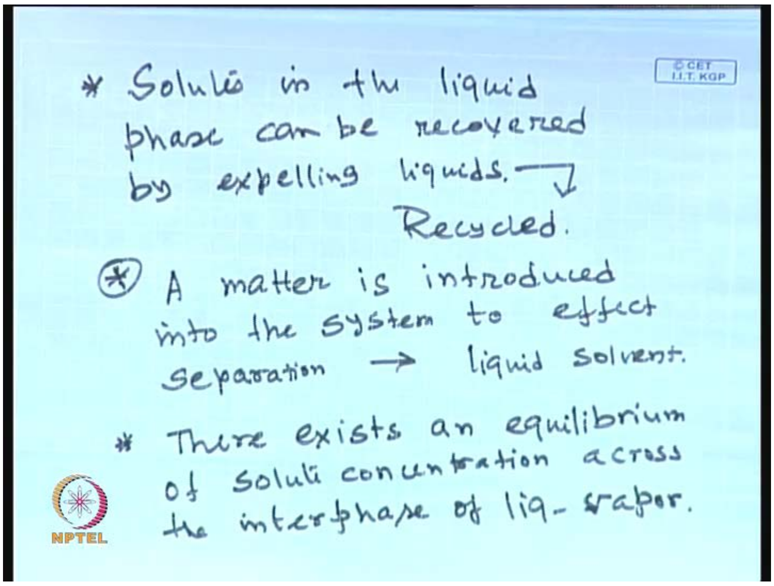

- Solutes in the liquid phase can be recovered by expelling liquids. → Recycled.
- A matter is introduced into the system to effect separation → liquid solvent.
- There exists an equilibrium of solute concentration across the interphase of liq- vapor.

The solutes in the liquid phase can be recovered, by expelling liquids you know there are several methods, for that and this liquid can be Recycled. So, here in this particular case it is not an energy a matter is introduced in this particular separation right. What is the matter the liquid; the solvent a an most of the absorptions are generally, they occur .Now, on the normal condition on room temperature; matter is introduced into the system to effect separation. What is that system? Is basically; liquid solvent and why it is equilibrium separation process, because they are exists there exist, an equilibrium of solute concentration; across the interface of liquid and vapor across.

The interface there is a know solid distribution, that will occur; it is it that distribution will be ruled under the equilibrium conditions. So, it is basically; the again; the equilibrium that, will dictate the maximum separation or maximum soluablisation of the solute from the vapor; into the liquid phase. So, again that will be it is, a case of equilibrium Governed Separation Process and the it is, the liquid solvent that will be basically; causing the separation.

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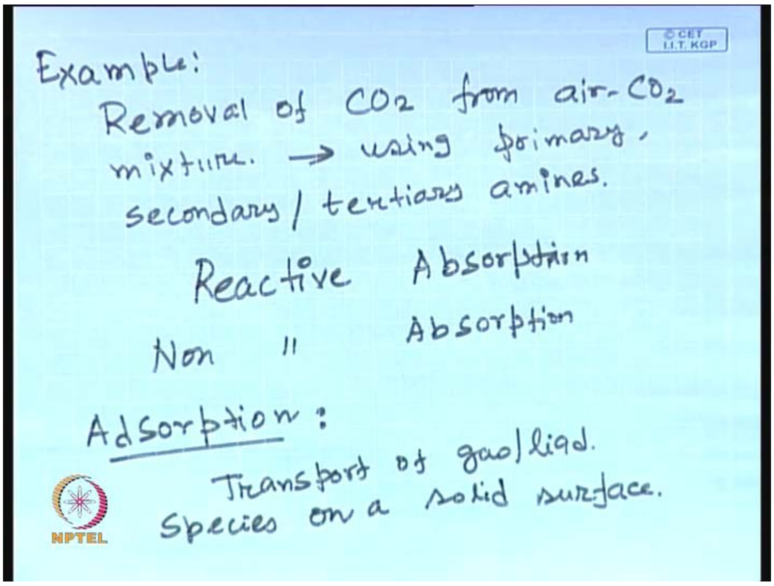

Example:

Removal of CO_2 from air-CO_2 mixture. → using primary, secondary / tertiary amines.

Reactive Absorption

Non " Absorption

Adsorption:

Transport of gas/liqd. Species on a solid surface.

Give an example, of the absorption process removal of the Absorption process for example, Removal of carbon dioxide from here, C O 2 mixture. So, one can use using primary secondary or tertiary amines are liquid compounds or solvents may be the primary secondary tertiary are different kinds of amines are available. Which are basically; liquid solvents, they will preferentially; Absorb carbon dioxide from a mixture from the air water air carbon dioxide mixture only carbon dioxide.

When they are in coming in contact with the amines solvent amine between air and carbon dioxide only; carbon dioxide will be preferentially; Absorbed into the into the amine these Absorption, can be Reactive Absorption can be a non Reactive Absorption, in case of non Reactive Absorption the amount, the solute will be getting transferred and it will be dissolved into the liquid stream. As a bulk phenomenon; and the case of on the, on the other hand in the case of Reactive Absorption the solute will be coming into the liquid phase; into the solvent phase, and it will be reacting with the solvent itself, or it can react with the particular, component that is present in the solvent for example, if a if a particular; species will be coming to the solvent and there is a particular species. Which will be reacting with the solute it will be reacting with the solute, and it will create a new compound. So, what is the effect the effect?. Is in the downstream in the solvent side the concentration of the particular; solute will become 0. So you can maintain always a maximum concentration gradient between the gaseous phase and the liquid phase. If, it is a reactive absorption the solute will be coming from the gas phase or vapor phase into the liquid phase, and it will be a reacting with the with the material, or the solvent itself so the concentration of the solute in the liquid stream become 0.

So, one can maintain the maximum concentration gradient in that, case and as for as equilibrium means at the interface. The you know rate of transfer of solutes, will be governed then, we come to the case of another equilibrium; Governed separation process that is adsorption, it is basically; the transport of gas or liquid species on a solid surface the for example, some organics are adsorb on activated carbon species activated carbon surface. So, adsorption compare to the absorption adsorption, is entirely; a surface phenomenon in the on the other hand the adsorption, Whatever; we have just discussed now the absorption is bulk phenomenon and the adsorption, is a surface phenomenon.

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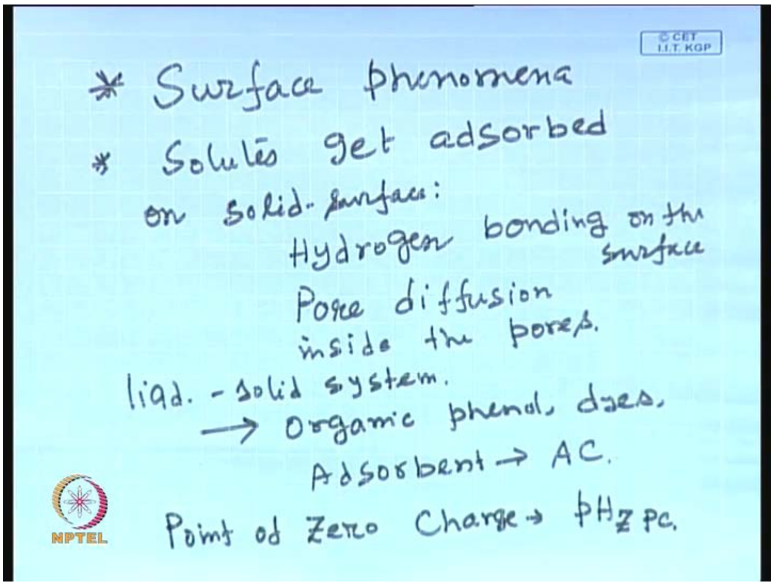

* Surface phenomena
* Solutes get adsorbed
on solid-surface:
Hydrogen bonding on the surface
Pore diffusion
inside the pores.
liqd. - solid system.
→ Organic phenol, dyes.
Adsorbent → AC.
Point od Zero Charge → pH_{zpc}.

So, a first characteristic of adsorption is that it is a surface phenomenon. The solutes get adsorbed on solid surface and it is basically; it is it will be attached; on a solid surface by several; in a physical chemical process, may be hydrogen bonding on the surface or there are another is that, there are fine pores present within the adsorbent. So, generally; adsorbents are very porous, so there are fine pores present, in the adsorbent in the adsorbent, itself and through this pores.

The solute will be the just entering into this pores these are called pore diffusion hydrogen bonding on the surface pore diffusion inside the pores. So, for example, it can be a liquid solid system. So, what is the liquid solid system? the liquid solid system is basically for example, if, you would like to remove any organic like phenol some dyes may be reactive dyes, like methylene blue crystal violet orange or red orange. So, there are many dyes and the adsorbent is called is activated carbon. Activated carbon contains lots of pores and it will be having generally, the surface of the typically it is normally; done that that, we try to make the surface of the adsorption, such that it has a opposite polarity, compare to the porous solute. If, you have a polar solute for example, alcohol or something those are those are all polar solute right. Now, if you have surface of the adsorbent the opposite polarity the opposite charge, then the bonding will be the absorption will be resolved and for example, in the in activates carbon the mostly; the surface are negatively; charged. How you know the surface is positively, charged, or negatively charged there is a particular test it is called point of 0 charged method p H Z PC 0 point charge. Now, there is a particular method, which exist and using the method and find out; what is the p H (( )).

The adsorption is neutral you can set your operating page (( )) are neutral page. There is Z PC p H that it, becomes positively; charged it becomes negatively, charged if, you set your operating page below the Z PC point. Then it will be positively; charged so, one can make the surface charged as per your wish by changing, or operating. The page of the solution, but before that you have to identify; the Z PC point or the Z PC p H of the adsorb adsorbent, the solute is called adsorbent and the material like activated carbon or something it is called adsorbent.

So, adsorbent that 0 point charge of the adsorbent has to be determinant. First you can set your operating page (( )) that if, f of the Z PC point or below the Z PC point depending upon the charge of the polarity of the solute. So, if you do that then the solute will be adsorb more on the solvent on the solute surface, an adsorbent, also there is pore diffusion there is may be competition of the pore diffusion, and the surface attachment may be a surface diffusion and because the solutes, will be coming and sitting in the surface.

It can immediately move either to the interior or over the surface itself, there may be a surface diffusion there may be interior pore diffusion. As well as there will be external attachment by hydrogen bonding or chemical bonding or it is something called chemise option? If, chemical bonding is more prevalent, that adsorption is known as chemise option. Otherwise known as physical adsorption by looking into the value of delta, H of the process one can come to a conclusion, or they it say chemise option or physical adsorption probably; the value will be around 10 calorie 10 or 12 calorie per mole something; more, if it is less than it is called physical adsorption, or otherwise it is chemical adsorption. Something like that so, there is a there is a criteria; existing by looking into the delta H value which will be dictating weather it will be physical adsorption, or chemical adsorption.

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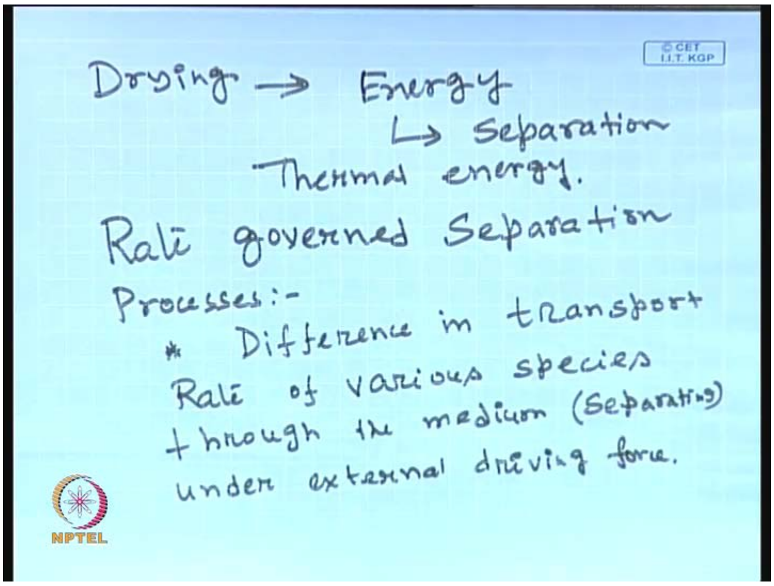

Drying → Energy
↳ Separation
Thermal energy.
Rate governed Separation
Processes:-
* Difference in transport
Rate of various species
through the medium (Separating)
under external driving force.

Another example of equilibrium Governed process is drying, you know drying is basically, the it is not a matter in the earlier process in case of adsorption, what is causing? The separation weather it is a matter of energy, it is matter that is causing separation in case of adsorption and the matter is adsorbent in case of drying. It is energy that causes separations and it is basically; the thermal energy.

Now let us, come so these are basically some of the compound equilibrium based separation processes that will come across, in chemical engineering in a stream and now let us, look into the Rate Governed separation processes. Now, in rate governed separation process is the basic characteristic, is difference in transport Rates of various species through, the medium separating medium is basically; a separating medium, under external driving force for example, osmosis and reverse osmosis in case of osmosis the external driving force is the concentration difference in case of reverse osmosis it is the pressure difference.

That will be causing that will be the external driving force, because of that there will be difference in transport of various species for example, the saline water is talking about; the transported of salt through, the separating medium; or the reverse osmosis membrane will be much less compare to transport. The solvent that is, water so, in the downstream. It will be it will be strips of salt upstream, which (( )) so, these are basically; rate governed separation processes.

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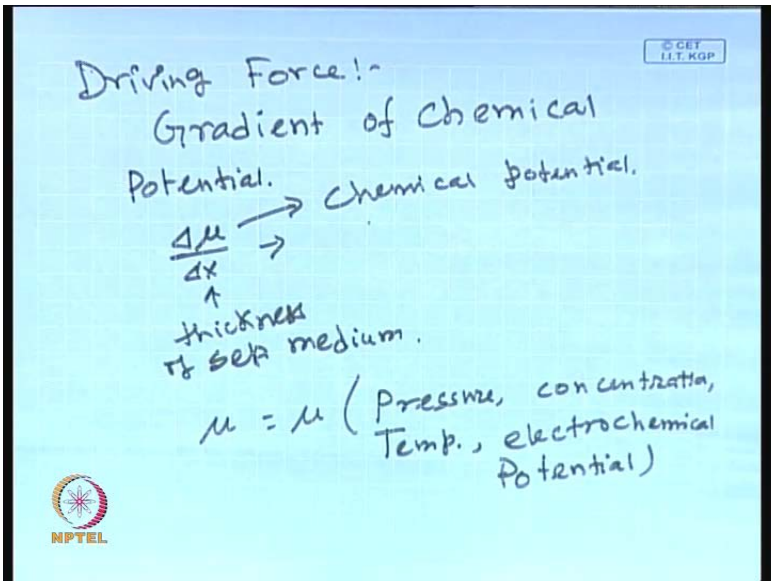

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Driving Force:-

Gradient of Chemical Potential. → Chemical potential.

$\frac{\Delta\mu}{\Delta x}$ →

↑ thickness of sep medium.

$\mu = \mu$ (Pressure, concentration, Temp., electrochemical Potential)

And in general the driving force of Rate Govern separation process is for the matter in the any separation process the driving force, is with the gradient of chemical potential, delta mu by delta, x if the thickness. There is a separating medium will be extremely, small the driving force will be extremely, high and the chemical this, this is the thickness of Separating separation, medium, this is chemical potential. And if, you just brush up your thermodynamics, chemical potential is a function of pressure concentration temperature, and electrochemical potential.

So, there are three components of there are four components of chemical potential pressure concentration temperature electrochemical potential. That means if, there may be transport occurring, because of the difference in either any of the four factors by any of these two factors. By any of these three factors, or any of these four factors, it means and the rate will be dictating according to that it means, rate will be having, the contribution, from difference in all the four factors.

If, all these four are varying suppose we are talking, about a system where it is isothermal that means the temperature gradient will be 0. So, in that case other three will be contribute and you know let us, talk about some of this even, if there is one or more of such know you causes; will be present as a gradient is gradient is not equal to 0. That will be transfer of a species across, the separating medium and these values, will be having difference effects on different solutes present, in the system these difference of Rates of transport of solutes will cause the separation in a Rate Govern separation process.

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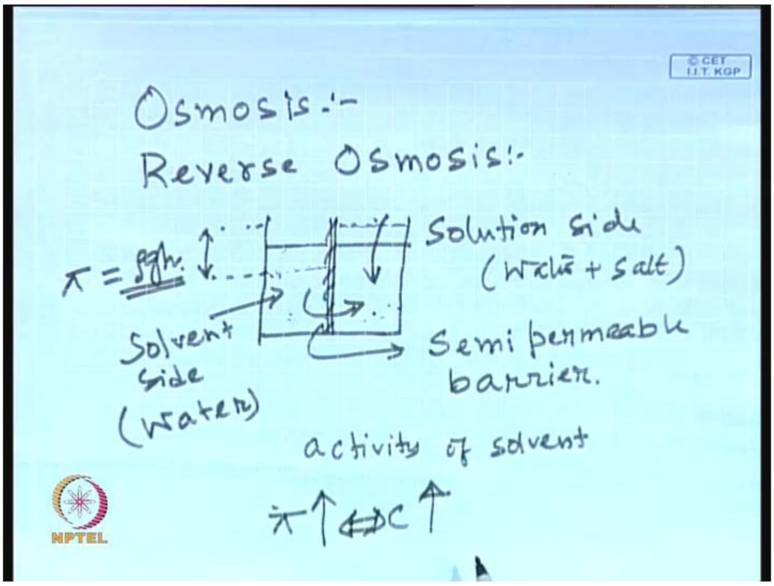

For example, Osmosis now let us, look in to the difference of osmosis and reverse osmosis that will clarify; some of our ideas and we will also discuss all these issues in greater detail and we talk about, the membrane based separation processes, suppose there are two chambers it is filled up, with water and it is separate, by a semi permeable barrier this is a semi permeable barrier. Why it is called semi permeable, because it will allow out of the two species let us, salt and water it will allow, only one particular; species to transport to get transported through, it and the other species will be retain by it.

So, it is called ideal semi permeable barrier. Now, what we do now we add some salt here so, this is called solution side and this is the solvent side and solvent is basically; nothing but water the solution is basically; water plus salt. Now, the salt concentration is less in this chamber and the salt concentration is more in the solvent side therefore, there will be a transport (( )) semi permeable membrane barrier. It will allow only the solvent to pass through, it will not allow salt to permit through it therefore, more water will be passing from the solvent side, to the solution side. So, in the effect the height of the solvent side will be decreasing and the height of the solution side, will be increasing and this process will continue unless and until the activity of solvent activity of solvent that means the activity, of water will become equal on both the sides or chemical potential, of water will become equal on both the sides.

So, this will and this process will continue unless there is equality, if activity of water on both the sides and at that case let us, say there will be a difference in their will be difference in height. If, you convert that height difference into pressure by multiplying, it by rho and gravity that, will that will cause you that is basically; the osmotic pressure of the system. Now, osmotic pressure is a colligative property. What is colligative property? Means some quantity which will be some property, of the liquid which will be function of it is concentration, the amount the concentration.

So, if you put more salt here the concentration of water will much less on this side in the solution side. So, more solvent or more water will be permitting from the solvent side to the solution side. So, in that case the height difference will be more (( )) more solvent will be passes these height will be for the lower, for the height will be more increased and your osmotic pressure will be higher therefore, depending on the concentration the osmotic pressure will increase and the relationship between, the osmotic pressure and the concentration of the solute will be ever increasing so more concentration. More osmotic pressure and of course, for a pure distilled water. So, there is no solute present the osmotic pressure is 0.

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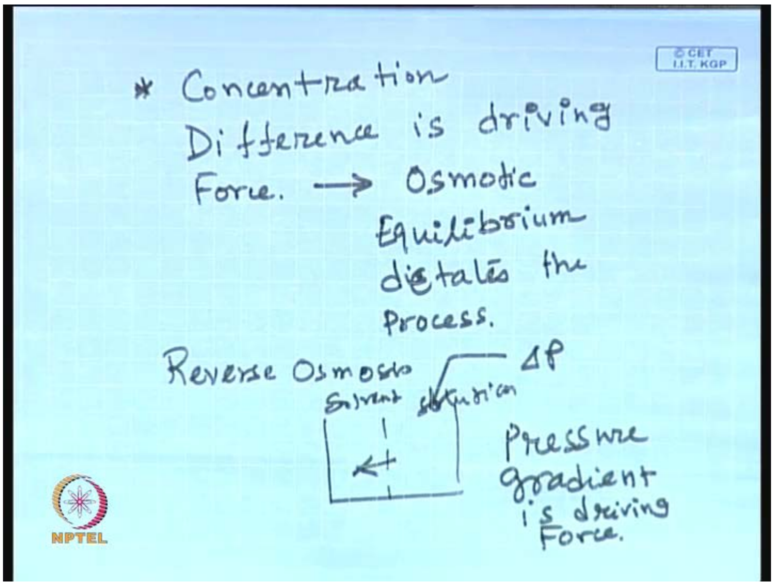

* Concentration Difference is driving Force. → Osmotic Equilibrium dictates the Process.

Reverse Osmosis

Pressure gradient is driving Force.

So, in this case the concentration difference is the driving force and it is basically, osmotic equilibrium that will be dictating the process dictates the process on the case of reverse osmosis. What we do suppose in the in the earlier diagram, this is the solution side this is the solvent side in a normal. Osmosis process the flow of solvent will be from the solvent side, to the solution, side in the reverse osmosis process.

We apply pressure from outside on the solution side and try to push out solvent from it therefore, the permit side in this case will be more in solvent that will be pure water will be you are going to get, and so, in this case of retentive in solution side it will be getting on concentrated. So, we since we are it is just opposite to the reverse of the osmosis process. You call it a reverse osmosis process so in this case pressure gradient, is the driving force right more pressure, will be giving the more solutes solvent will be ejected out of the solvent side so, pressure gradient will be driving force so, let us, stop it for today and tomorrow.

What we will be doing will be studying, some more characteristics of the Rate Governed separation processes and look into the other you know driving forces for example, in a temperature difference, electrochemical potential difference, and then we try to summarize, the you know between the equilibrium Govern separation process Rate Governed separation, process to identify, which separation process should be categorized as novel, separation process for further discussion.