Material and Energy Balances

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Module No # 04
Lecture No # 18
Material Balance Calculations on Relative Processes Tutorials

Hello everybody today we will have a tutorial session on material balances for reactive process we have looked at all the fundamental concepts which are involved in performing material balances for reactive processes we have try to solve calculation and problem which involved multiple reaction and also multiple units which had reaction happening. So today we will try to perform more example problems which will help us familiarize with the approach for material balance problems with reactions let us move on to the first problem.

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Problem #1

- The company you work for produces alanine. Alanine is a nonessential amino acid synthesized by the body. It is important as a source of energy for muscle tissue, the brain and the central nervous system. Alanine also helps in the metabolism of sugars and organic acids. Alanine is produced in a reactor in a continuous process. There are two separate inlet streams that contain glutamine (100 mol/min) and pyruvic acid (50 mol/min), respectively. The ratio of the molar flow rate of pyruvic acid in the outlet stream to that in the inlet stream is 0.6.

$C_5H_{10}N_2O_3$ (glutamine) + $C_3H_4O_3$ (pyruvic acid)

→ $C_5H_7NO_4$ (α-ketoglutamic acid) + $C_3H_7NO_2$ (alanine)

Find the limiting reagent. What is the extent of reaction, ξ, of glutamine and pyruvic acid? What are the fractional conversions of glutamine and pyruvic acid? Find the outlet molar flow rates of alanine, α-ketoglutamic acid, and any excess reactants.

Problem adapted from Saterbak, McIntire, and San, Bioengineering Fundamentals, 1st Edition, Pearson

The company you worked for produces alanine, alanine is an non-essential amino acid synthesis by the body it is important as source for energy of muscle tissue and brain and the center nervous system alanine also helps in the metabolism of sugar and organic acids. Alanine is produced in a reactor in the continuous process there are two separate inlet stream that contains glutamine at 100 moles per minute and pyruvic acid which is 50 moles per minute.

The ratio of the molar of pyruvic acid in the output stream to that in the inlet stream is 0.6 so the reaction is glutamine reacts with pyruvic acid to from alpha - ketoglutomic acid and alanine find the limiting agent what is extent of reaction (()) (01:49) for glutamine and pyruvic acid what are the fractional conversion of conversion and pyruvic acid find the molar output flow rates of alanine alpha ketoglutomine and excess reactants.

So this is the simple unit process with single reaction unit so here it is a reaction where glutamine reacts with pyruvic acid to for alpha ketoglutmic acid and alamnine we have also been given through molar flow rates for the reactant glutamine and pyruvic acid and we have also been told what is the ratio of outlet to inlet streams for pyruvic acid.

So using this information we now need to calculate how much of pyruvic acid is consumed what is the conversion how much of glutamine its consumed and what is the convers based on glutamine and we should also calculate the composition of the exit streams and the extent of reaction. Let us go ahead and try to solve this problem.

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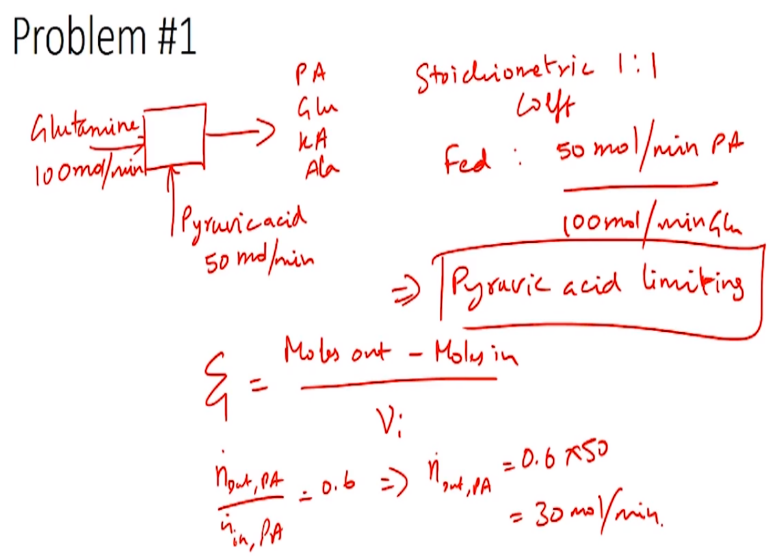

Based on the information we can draw this simple flow charts where we have two inlets and one outlet the first inlet would be for glutamine and this would basically have a flow rate of 100 moles per minute and the other inlet is pyruvic acid which flows at 50 moles per minute you have an exit stream which would react at unreacted pyruvic acid unreacted glutamine the products kitoglutomine acid and alanine.

So this would be a product stream so now we need to first identify which of these two is the limiting reactants. So the stoichiometric coefficient for both these reactants is 1. So which means ratio one of the stoichiometric coefficient is also 1 so here it is fed as 50 moles of pyruvic acid per minute 100 moles of glutamine per minute. So this means pyruvic acid is the limiting reactants and glutamine is supplied in excess.

So the first aspect we have calculated now the next thing is we need to calculate the conversion the extent of reactions for the reaction using glutamine and pyruvic acid so we have the extent of reaction definition as moles of component out – moles in divided by that stoichiometric coefficient of that particular component. Here we are looking at the reaction and pyruvic acid which means though the stoichiometric coefficient would be -1.

So we need to identify moles coming out for glutamine and pyruvic acid to calculate the extent of reaction. We have been given that the moles of pyruvic acid leaving divided by moles of pyruvic acid entering = 0.6. So we already know the moles of pyruvic acid which is 50 moles so the number of moles of pyruvic acid which is leaving the system as unreacted pyruvic acid would be 0.6 times 50 which equals 30 moles per minute.

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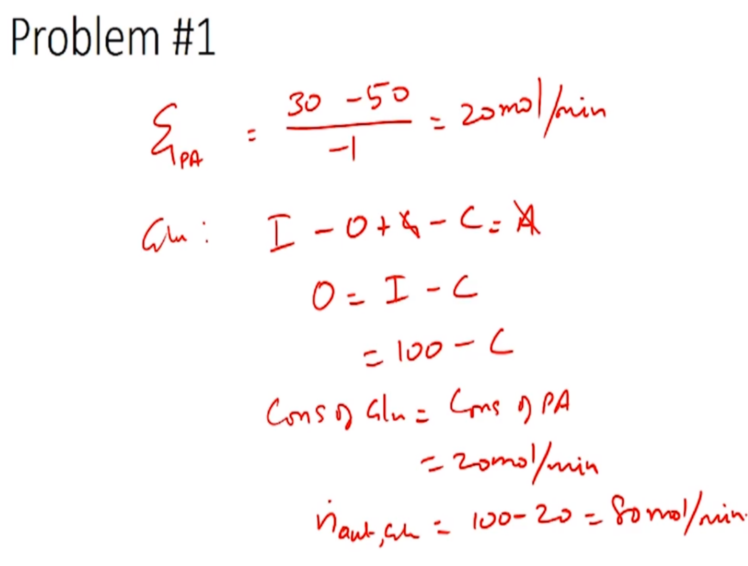

So 30 moles of pyruvic acid is leaving the system per minute so the extent of reaction using pyruvic acid would be so moles out which is 30 – moles in which is 50 divided by the stoichiometric coefficient which is -1 giving extent of reaction as 20 moles per minute we know that the extent of reaction will be the same for any component in the reaction. So the extent of reaction for glutamine should also be 20 but however let us calculate and confirm it is actually 20.

So would we do that we need to know the number of moles of glutamine which is leaving the system so using stoichiometric sorry using material balance for glutamine we can write the balance equation as input – output + generation – consumption = accumulation at steady state there would not be any accumulation. So glutamine actually a reactants it not been generated so you have only input output and consumption so your output would have been equal to input – consumption.

We know that the input is 100 moles we have to look at what the consumption would be looking at the stoichiometric we know that for every mole of pyruvic acid consumed one mole of glutamine is also consumed therefore consumption of glutamine = consumption of pyruvic acid which is equal to 20 moles per minute. So the number of moles of glutamine leaving the system would be 100 – 20 giving you 80 moles per minute.

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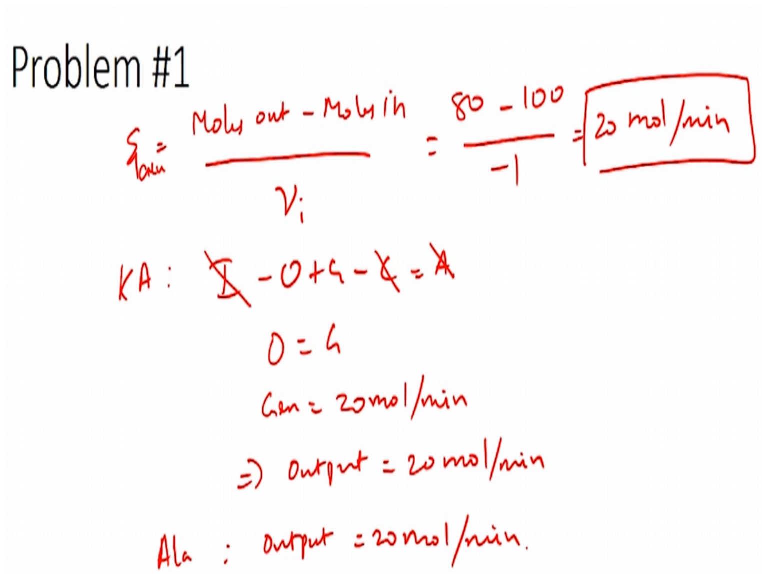

So hence we can calculate the extent of reaction for glutamine as moles out – moles in divided by stoichiometric coefficient which would be moles out is 80 – 100 is the moles in divided by the stoichiometric coefficient of -1 again giving you 20 moles per minute so this would be the extent of reaction using glutamine. As we expect the extent of reaction is same for when we calculated using glutamine or using pyruvic acid.

So the next aspect we have to identify is number of moles of product of unreacted reactants which are leaving the system. So we can write the balance equation for the products so if where to write a balance for kitogluetamic acid it would be input – output + generation – consumption = accumulation at steady state accumulating goes to 0 it is product it is not consumed it is not coming in so you would end up with output = generation.

So using stoichiometric for every mole of glutamine consumed 1 mole ketoglutamic acid is produced so this would mean that generation = 20 moles per minute so this would also be the output moles per minute.

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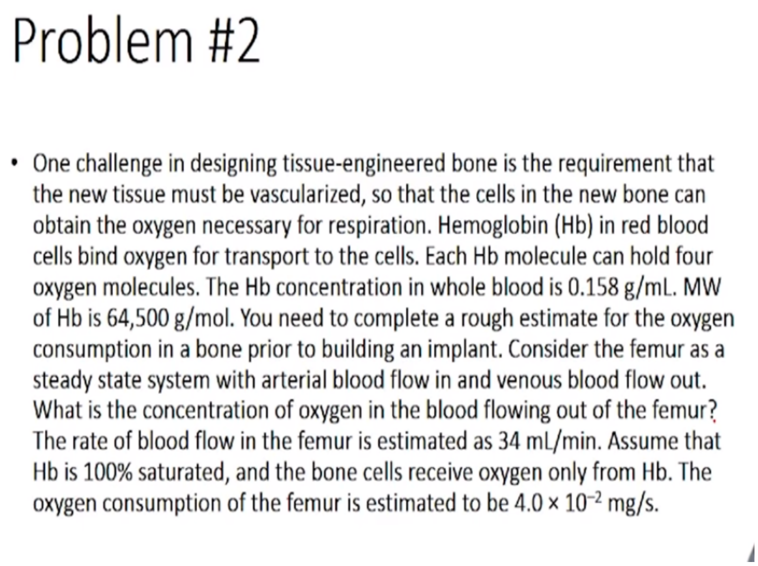

The final product stream we have would contain 30 moles per minute of pyruvic acid 80 moles per minute of glutamine and 20 moles per minute of katoglutomaic acid and 20 moles per minute of alanine which are leaving the system so this would be exit stream. So we also have been asked to calculate the fraction conversion of glutamine and pyruvic acid. So conversion of glutamine would be equal to the number of moles of glutamine consumed divided by the number of glutamine fed.

So this is 20 divided by 100 giving you conversion of glutamine as 0.2 and conversion of pyruvic acid would be equal to number of moles of pyruvic acid consumed divided by the numbe of moles of pyruvic acid fed. Which would be 20 divided by 50 giving you 0.4 as the conversion of pyruvic acid. So with this we have solved this simple problem and we have been able to calculate all the parameters that were asked.

So let us look at another example problem which would be a little more complicated simply because for the biomedical system and the reaction is not given expressly so we have already done problem similar this so we will again try a problem here where the stoichiometric is not known however the generation and consumption terms has been given to us in a indirect way.

So the problem statement one challenged designing tissue engineered bone is the requirement that the new tissue is vascularized so that the cells in the new bone can obtain oxygen necessary for respiration. Hemoglobin in red blood cells bind oxygen for transport to the cells each hemoglobin molecule can hold four oxygen molecules the hemoglobin concentration in whole blood is 0.158 grams per ML.

Molecular weight of Hemoglobin is 64500 grams per mole you need to complete a rough estimate for consumption in bone prior to building an implant consider the femur as a steady state system with arterial blood flow in venous blood flow out what is the concentration of oxygen in the blood flowing out of the femur the rate of blood flow in the femur estimated to be 34 ML per minute.

Assume that hemoglobin is 100 % saturated and the bone cells receives oxygen only from hemoglobin the oxygen consumption of femur is estimated to be 4 times 10 power -2 milli grams per second. So all the information we need or the problem have been given to us let us see how we can solve the problem.

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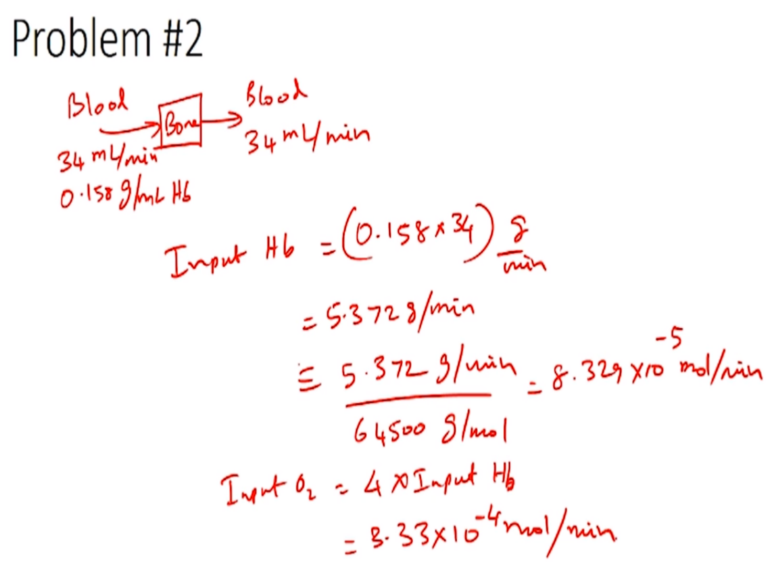

The problem statement clearly tell us that femur can be assumed as the system with a single input and the single outlet this inlet being arterial blood flow in and outlet being venous blood flow out so we can draw a simple flow chart which would basically looks like this. So this is the gone and you have atrial blood coming in and venous blood leaving and we have also been told that the flow rate of blood 34 ML per minute and the blood contains 0.158 grams per ML of hemoglobin.

So this information is available to us we also have been asked to assume the steady state which means the flow rate of blood outside which is leaving the blood would also bone would also be 34 ML per minute. So now we need to identify how much oxygen is actually entering and leaving the system and we have to calculate the consumption based on the information given to us.

So for this we would have to write an oxygen balance for this system before we start with the oxygen balance we need to know how much hemoglobin is actually entering the system so that we can calculate the number of moles of oxygen which is being carried by the hemoglobin into the system. So for that reason we will first calculate input hemoglobin so we know that the concentration of hemoglobin is 0.158 grams per ML and the flow rate of blood is 34 ML per minute.

Which means the mass of hemoglobin which is entering the system would be 0.158 multiply by 34 gram per minute. So this would be equal to 5.372 grams per minute. So we now have the mass which is entering the system. However we know that 4 molecules of oxygen are attached to 1 molecule of hemoglobin at 100% saturation.

So we need to know the number of moles of hemoglobin so that we can calculate the number of moles of oxygen which is being carried by 100% saturated hemoglobin. So for this we would have to convert the mass of hemoglobin to mole of hemoglobin which we can do by using the molecular rate given to us so gram per minute divided by 64500 gram per mole giving us the molar flow rate of hemoglobin into the system as 8.329 times 10 power -5 moles per minute.

So from here we can calculate the number of moles of oxygen entering so the input oxygen would be = 4 times input hemoglobin because we are asked to assume 100% saturation we would just be able to do this and the calculation would give us 3.33 times 10 power -4 moles of oxygen enters per minute. So we also need to calculated the amount of oxygen which is consumed so that we can actually calculate the amount of oxygen which would be leaving the system.

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Problem #2

O_2 cons $= 4\times10^{-2}$ mg/s $\cong 2.4$ mg/min

$= 7.5\times10^{-5}$ mol/min

O_2: $I - O + G - C = A$

Out $= I - C$

Output $= 2.58\times10^{-4}$ mol/min

So oxygen consumed has been given to us so which would be 4 times 10 power -2 milligrams per second so converting this to milligrams per minute it would be equal to 2.4 milligrams per minute so we can convert the rate of consumption of oxygen in terms of mass to moles using the molecular weight which should be equal to 7.5 times 10 power -5 moles per minute.

So we are converting milligrams to grams and then converting grams to moles so this is the number of moles of oxygen consumed. So that we have identified the input and consumption for oxygen we can write an oxygen balance for the bone which would be input – output + generation – consumption equals accumulation at steady state there is accumulation oxygen is not being generated.

So output is basically equal to input – consumption so out is equal to 2.8 times 10 power -4 moles per minute so this is the molar flow rate for oxygen which is leaving the system. To calculate the concentration of oxygen which is leaving the system we would have to convert this molar flow rate into mass flow rate and divided by the volume which is leaving the system. So the volumetric flow rate is 34 ML per minute and the molecular weight is 32 grams per mole for oxygen.

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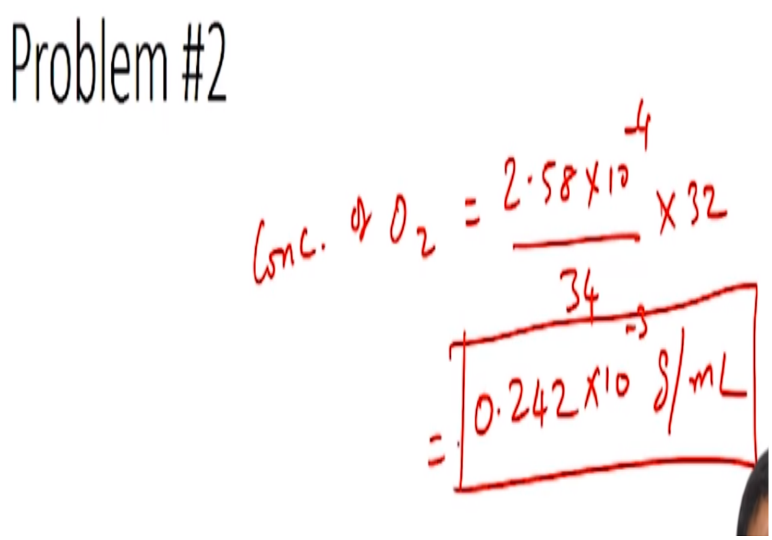

So the concentration in terms of grams per ML or milligrams of ML would be 2.5 times 10 power -4 divided by 34 which is the o=volumetric flow rate times 32 which is the molecular weight so this gives you a value of 0.242 times 10 power -3 grams per ML. so this would be the concentration of oxygen which is leaving the mole so again we have been able to perform the required material balance calculation using the consumption term which has been given in terms of rate of consumption instead of stoichiometric.

We have been able to identify the concentration of water which is leaving the system so with this we have actually seen two different example problems where we have used single reactions and a single unit system. So in the next problem we will look at something which is little more complicated.

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Problem #3

- To produce acetylene, C_2H_2, pure methane and pure oxygen are combined in the burner, where the following reactions occur:

$$CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$$

$$CH_4 + 1.5O_2 \rightarrow 2H_2O + CO$$

$$2CH_4 \rightarrow C_2H_2 + 3H_2$$

The gases exiting the burner are cooled in the condenser that removes all the water. The gas leaving the condenser contains 8.5% C_2H_2, 25.5% H_2, 58.3% CO, 3.7% CO_2, 4.0% CH_4. This gas mixture is sent to an absorber, where 97% of the C_2H_2 and all of the CO_2 are removed with the solvent. The solvent from the absorber is sent to the CO_2 stripper, where all the CO_2 is removed. The gas stream leaving the top of the CO_2 stripper contains 92.5% CO_2 and 7.5% C_2H_2. The solvent from the CO_2 stripper is pumped to the C_2H_2 stripper, which removes all the C_2H_2 as a pure product. Using the basis of 100 moles of gases leaving the condenser,

  - Calculate the ratio of the moles of O_2 to moles of CH_4 fed to the burner.
  - Calculate the mass of water removed by the condenser.
  - What is the overall percentage yield of product C_2H_2 (pure), based on the amount of methane entering the burner?

Problem adapted from Himmelblau and Riggs, Basic Principles and Calculations in Chemical Engineering, 7th Edition, Prentice Hall India

So this is the problem so here we have multiple reaction which are happening in parallel and there also multiple units which are also present in the system so let us look at this problem. To produce acetylene pure methane and pure oxygen are combined in the burner where the following reactions occur.

Where methane reacts with 2 moles of oxygen to produce carbon dioxide and water methane reacts with 1.5 moles of oxygen to produce two moles of water and one moles of carbon monoxide two moles of methane is dehydrogenated to form acetylene and hydrogen gas. The gases which are exiting the burner are cooled in the condenser which removes all the water the gas leaving the condenser contains 8.5% acetylene 25.5% hydrogen 58.3 % carbon monoxide 3.7% carbon dioxide 4% methane.

This gas mixture is sent to an absorber where 97% of acetylene and all the CO2 are removed with the solvent. The solvent from the absorber is sent to the CO2 striper where all the CO2 is removed the gas stream leaving the tip of CO2 stripper contains 92.5% carbon dioxide and 7.5%

acetylene. So solvent form the carbon dioxide stripper is pumped to the C2H2 stripper where all of C2H2 is removed as pure product.

Using the basis of 100 moles of gas leaving the condenser calculate the ratio of the moles of oxygen to the moles of methane fed to the burner calculate the mass of water removed by the condenser what is the overall percentage yield of the product which is acetylene pure based on the amount of methane entering the burner so now this is a much more complicated problem than what we have been looking because there are multiple reaction and also multiple system let us try to gather all the information and draw the flow char for the system.

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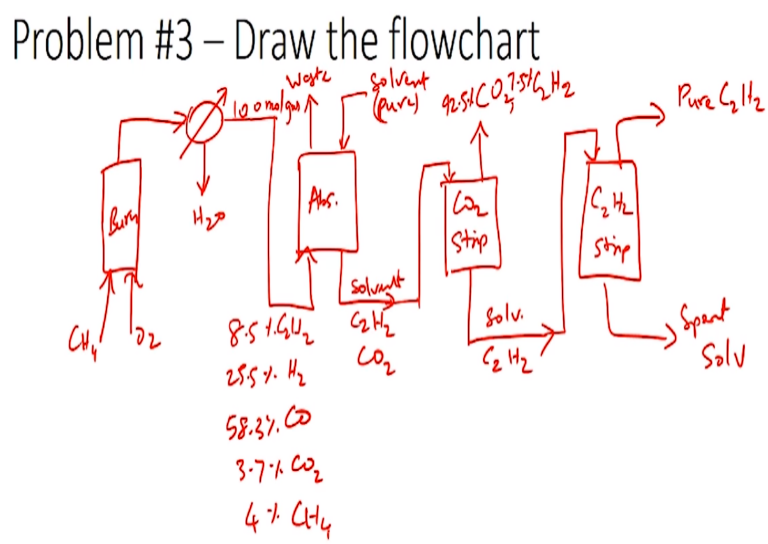

The problem statement gives us that there is a burner to which methane and oxygen are fed so you have methane and oxygen fed the burner so the reaction which have been stated happen within this burner which is the reactor and the gases which is comes out are sent to a condenser. So in this condenser water is removed all the water vapor which is leaving the burner is removed as liquid burner from the condenser.

The non-condensable component are then sent to an absorber so let this be the absorber and in the absorber you also have a solvent we have not been told to what solvent it is it is some pure solvent which is being fed o the absorber and this solvent carries out all the CO2 and 97% acetylene in the liquid form. So this would be the solvent with the C2H2 97% of C2H2 and all of the CO2 and this solvent is then sent to CO2.

So obviously there would also be waste gases leaving because other gases like carbon monoxide and other gases which are formed would also be leaving through the waste gas stream. So now this solvent which carries and acetylene and carbon di oxide is sent to CO2 a carbon dioxide stripper where you have carbon dioxide which is removed along with acetylene gas and it is been told that the composition this is 92.5% carbon dioxide and the rest 7.5% is acetylene.

So you have a liquid stream leaving which would contain solvent and C2H2 only all the CO2 is removed in the gas phase. So now you have a solvent which carries the acetylene and this is then sent to an acetylene stripper C2HO2 stripper where pure acetylene is collected as the product so obviously the spent solvent which is leaving this system. So this would be a flow chart and base on the information given we have to assume that the gases leaving the condenser which is this particular stream would be 100 moles.

So that is the basis we are supposed to use and we also been given that this stream is 8.5% acetylene 25.5% hydrogen 58.3% carbon monoxide 3.7% carbon dioxide and 4% methane. So we now have information that has been given to us in the problem captured in the form of the flow chart.

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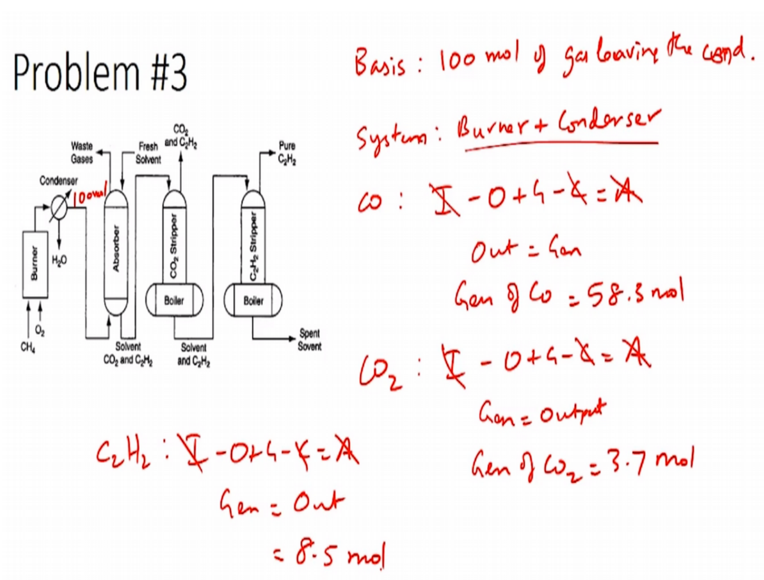

Let us try to solve this problem based on the information given in the problem we have chosen the basis as 100 moles of gas leaving the condenser so this is the basis so which means this would be 100 moles so this particular stream leaving the condenser is 100 moles now we need to identify how much of water is condensed we also need to identify how much of acetylene is recovered and also the ratio of methane to oxygen.

So the first part is to identify methane to oxygen ratio how do we start with that what would be system which we choose. So in many cases we have used the overall system to start with may calculation involving multiple process multiple units however here if you were to use to overall system it can actually been very confusing because we do not have all the information about many of this streams.

However we can start with the different approach he approach which we were used either to start with last unit or first unit. So here we could choose to use the unit however we do not have the information about the exit stream which is leaving the burner the information we have for the for this is for the gas stream which is leaving the condenser. So the first system which we can choose would be for the burner + condenser.

So this system we have information about exit stream we know the number of moles we have the composition we do not know the number of moles of water we know that only water so we just have to calculate methane and oxygen which is being fed and using simple material balances this can easily be done. For the system which is the burner + the condenser let us start writing the component balances.

The first component balances we can write is CEO balance this would be input – output + generation - consumption =accumulation at steady state there would not be any accumulation. CO is being generated it is being a product in one of the actions so there is no consumption of carbon monoxide there is not carbon monoxide entering the system so methane and oxygen entering the system.

So your output = generation there output = generation so we know that the composition of this stream as 58.3% CO so the output contains 58.3 moles of carbon monoxide so generation of carbon monoxide would be 8.3 moles similarly we can write a balance equation for carbon dioxide again input – output + generation – consumption = accumulation goes to 0 at steady state there is no consumption or input for carbon monoxide carbon dioxide.

So your equation against simplifies to generation = output we have information about output for carbon dioxide which is told that 3.7% is the composition of molar composition of carbon dioxide in the gases which is leaving the condenser. So generation of carbon dioxide would be equal to 3.7 moles similarly we can write an acetic acetylene balance C2H2 balance would again being input – output is generation – consumption =accumulation.

Accumulation consumption and input goes to 0 so becomes generation = output and using the composition of gases leaving you know 8.5 moles o acetylene is leaving which means hat is the number of moles of acetylene which is generated in the burner. Now that we have identified how much of each of the product is generated form the reaction 1, 2 and 3 given in the problem.

We can calculate how much of the reactant would have been consumed and once we have the amount of methane and oxygen consumed we already know the amount of methane and oxygen leaving we can calculate the amount of methane and oxygen is entering the system So this we can do by writing balances for methane an oxygen.

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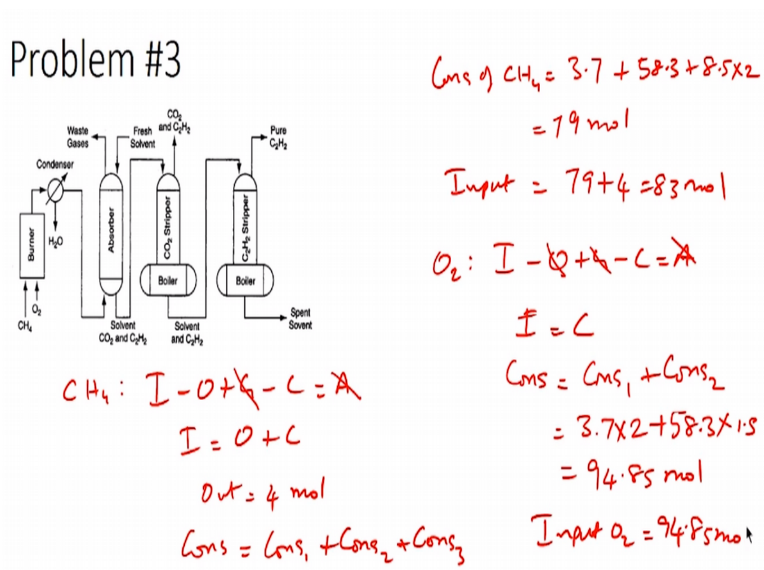

So let us start with the methane balance so again input – output + generation – consumption = accumulation and steady state there would not be accumulation and we do not have any generation of methane because it is the reactants. So you are having input – output = consumption = 0 so your input would be equal to output + consumption. So output we have already know that it is 3.7 output is already known as 4 moles of methane because 4% is the mole percentages of methane in the gas leaving so output is already known as 4 moles now we need to identify consumption.

Consumption of a methane happens in all the three reactions methane is consumed by reaction 1 to produce carbon dioxide from reaction 2 to carbon monoxide and reaction three to produce acetylene. So your consumption term would have three reference consumption 1 and consumption 2 and consumption 3. So looking a the stoichiometric for every mole of carbon dioxide produced on mole of methane is consumed.

For every mole carbon monoxide priced there is one mole of methane which is consumed for every mole of acetylene produced two moles of methane is consumed using that stoichiometric we can basically calculate the consumption of methane as 3.7 which is the number of moles of carbon dioxide generated + 58.3 which is the number of moles of carbon dioxide generated + 8.5 times 2 where 8.5 times by number of moles acetylene generated.

Because we have two moles of methane being consumed per mole of acetylene we are multiplying with two which is the stoichiometric coefficient we get the consumption of methane as 79 moles. So input for methane would be equal to 79+ 4 which is 83 moles of methane similarly we can write oxygen balance. So for oxygen balance you have input – output + generation - consumption = accumulation.

No accumulation generation or output because we see that there is no percentage of oxygen given in the exit stream for from the condenser which would mean there is no oxygen leaving so all the oxygen is consumed. So input = consumption we do not need to identify what the consumption is so the consumption for oxygen would again happen through this reactions reaction 1 and 2 both consume oxygen.

So you would have to identify the consumption of oxygen in the first reaction and consumption of oxygen in second reaction using the stoichiometric of reaction given we know that for every mole of carbon dioxide used two moles of oxygen is consumed similarly for every mole of carbon monoxide produced 1.5 moles of oxygen is consumed. So this would be the consumption of oxygen = generation of carbon dioxide times 2 + generation of carbon monoxide times 1.5 so the consumption = 94.85 moles.

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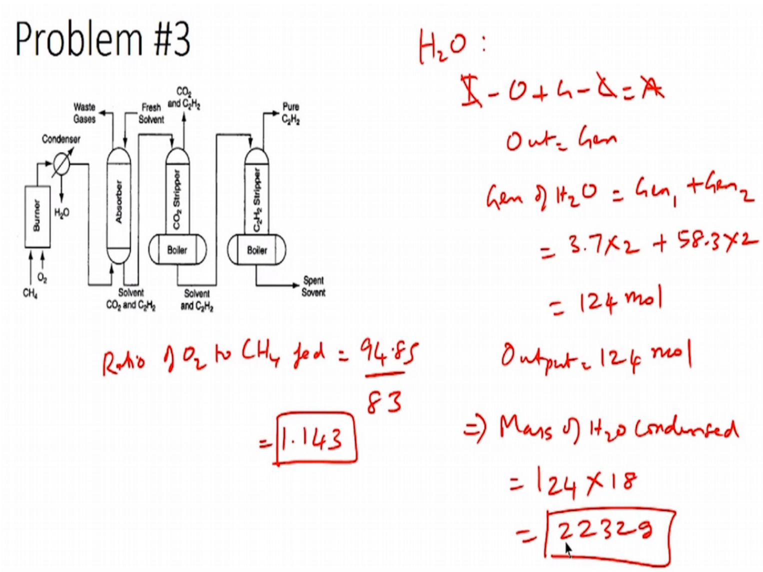

So therefore input of oxygen = 94.85 moles so based on this we can calculate the ratio of oxygen to methane fed as 94.85 divided by 83 which is equal to 1.143 so this is the ratio of oxygen to methane which is being fed. So the next aspect we need to calculate is the number of moles of water the mass of water which is condensed from the condenser that we can obtain using the water balance for the same system so in this system water is crossing the system boundary.

So we can use the same system which is the burner + the condenser forming the calculation so let us write the water balance would again be input – output + generation – consumption =accumulation are steady state there would not be accumulation and no condensing or input term so your equation becomes output = generation so we need to identify how much water is being generated.

Water is generated by reaction 1 and 2 so the generation of water would be equal to generation to reaction 1 and generation to reaction 2. So looking at the stoichiometric every mole of carbon dioxide produce two moles of water is produced and for every mole of carbon monoxide produced there are two moles of water produced. So this is 3.7 times 2 moles of water generated by reaction 1 + 58.3 times two moles of water generated from reaction 2.

So giving you 124 moles of water which is generated so water output = 124 moles so this implies mass of water removed or condensed would be equal to 124 times 18 which 22320 grams.

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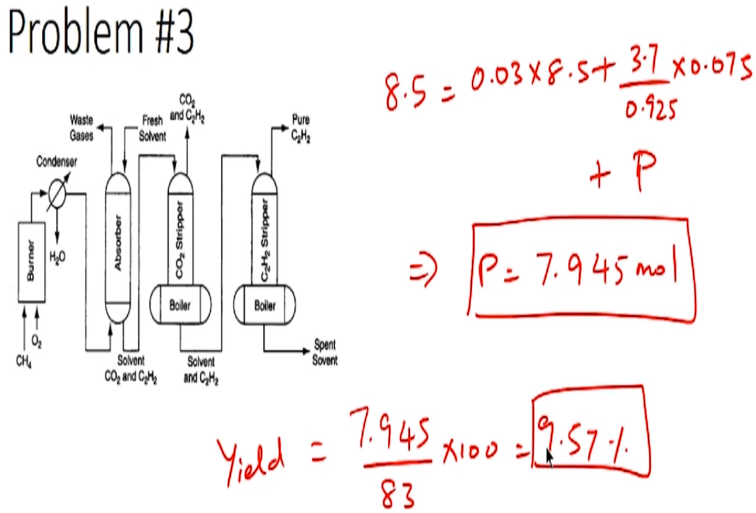

The last part of the problem ask us to calculate the yield of acetylene which is pure product based on the amount of methane fed to identify this we have to calculate the amount of acetylene which is leaving from the system we already know the amount of moles fed. So to get this pure acetylene which is leaving we can choose a system which would basically have the all the other component except the burner and condenser as the system.

So when we choose this system what we have is you have that gases the mixed gases coming in and you have waste gases leaving and then you have carbon dioxide and acetylene leaving through the CO2 stripper and you have the pure acetylene and we have the solvent leaving. So we are not interested in knowing information about the solvent we do not have to worry about the solvent or what are the flow.

So we just identify the acetylene based on the information given we know that the composition of this gas stream which is an observer contains 8.5% acetylene so which means the basis of 100 kilo moles of gas we have 8.5 moles of acetylene which is entering the absorber or entering the system the chosen. So the equation for acetylene the equation for acetylene be input – output + generation – consumption = accumulation.

So here there is not accumulation because of steady state and there are no generation or consumption term because the system it is chosen are non reactive system so the reaction simplifies to input = output so the input is 8.5 moles which we already know based on the information given to us in the problem. Now we need to identify the different output stream acetylene is leaving through the waste gases have acetylene leaving here and you have acetylene leaving here and acetylene leaving here.

So there are three different output streams for acetylene so we need to identify how much acetylene is leaving through individual streams how do we go about doing that? So this waste gas has 3% of acetylene and 97% of acetylene leaves along with the solvent this as been given to us in the problem. So this means acetylene in waste gas C_2H_2 in waste gas would be equal to 0.03 times 8.5 moles.

So this would be the first exit stream so now the exit stream we have is acetylene leaving along with carbon dioxide form CO_2 stripper so the information we have is CO_2 constitutes 92.5% and acetylene constitutes 7.5% of this stream and we know the CO_2 is not leaving the system through any other stream so all the CO_2 which is entering would have to be leaving only through the stream.

So if you were to write the CO_2 balance we would have input equals output and the output would be only through the stream based on the information we have about composition of gas the output would be 3.7 moles. So 3.7 moles account for 72.5% so this implies COC_2H_2 in the CO_2 stripper exit gas would be equal to 3.7 divided by 0.925 times 0.075 so this would be the second exit stream.

The third exit stream is what we are interested in which we can calculate using the material balance. So let us write the material balance so we have 8.5 equals 0.03 times 8.5 + 3.7 / 0.925 times 0.075 + pure C_2H_2 which is call as P and using this we calculate P as 7.945 moles. So that tis the number of moles of acetylene product which is recovered. So the yield for acetylene based on methane fed would be 7.949 divided by 83 times 100 giving a percentage yield of 9.57% so this helps so this gives us all the parameters that have been asked for the problem.

So now we have looked at different types of problem where there are single or multiple reactions and single of multiple units we have looked at applying the same fundamentals associated with material balances we have been able solve for all the required parameters. So please practice more problem using text books that have been prescribed and that will help you understand the approach which is being taken for solving such problems thank you.