Environment Engineering: Chemical Processes
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Module No # 05
Lecture No # 25
V MINTEQ: TITRATION AND MULTISWEEP BUFFER: INTRODUCTION

Hello everyone, welcome back to our latest lecture session. So in the previous session we looked at the relevant theoretical basis for looking at calculating the equivalence point. When you are titrating weak base with the strong acid and we know that the PH of the equivalence point would depend upon the PKB of your particular weak acid and also to a little ex10t not to a great ex10t though on your total base present in your system.

So in today's session we are going to primarily look at application of V minteq and then if given the time or time constraints, we are going to move on buffering I guess, so let us switch over to V minteq here.

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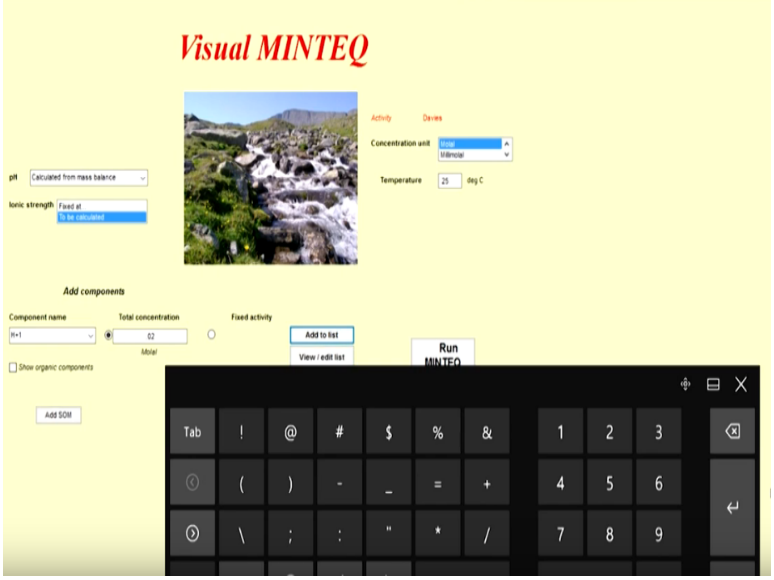

pH: Calculated from mass balance
Ionic strength: To be calculated
Activity: Davies
Concentration unit: Molal
Temperature: 25 deg C
Component name: H+1
Total concentration: 02 Molal

So now we are going to look at how to look at the applications of titration in our particular system here. So we will look at 2 examples, one when we have the H2 CO3 + present in our system. So let us choose the relevant components for that so I am going to say CO3 total and let us go with again as the same case as last time 0.001, 0.01.

For now 0.01 and we will add that to the list and then the other component obviously is going to be H+ and CO 32- here is 0.01. Our H+ needs to be H total needs to be 0.02. So I am going to add that to the list and obviously why is that because H 2 CO 3 is our initial source or the DCP. So let us just look at why I am saying? I am adding

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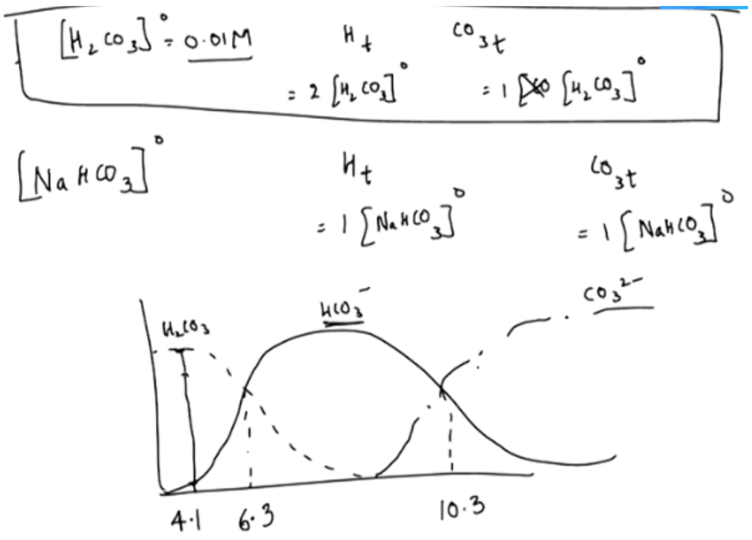

$[H_2CO_3]^0 = 0.01M$ $\quad H_t = 2[H_2CO_3]^0 \quad CO_{3t} = 1[H_2CO_3]^0$

$[NaHCO_3]^0$ $\quad H_t = 1[NaHCO_3]^0 \quad CO_{3t} = 1[NaHCO_3]^0$

H2CO3 to the system, so if I am choosing H total and CO3 total. What does the component balance going to be equal to? It is going to be equal to 2 times H2 CO 3 concentration added initially and CO3total is going to be equal to one times the H2 CO3 added initially and again obviously if I am choosing NA H CO 3 as my species or the concentration or the compound.

Initially what would be H total? Then it is now going to be equal to one times Na H CO3 naught and CO3 total that is going to be equal to one times Na H CO3 naught again for those particular, we will take example we are looking at this particular scenario when H2CO3concentration is equal to 0.01 molar. So again let us go back to V minteq here and let us look at the view edit list.

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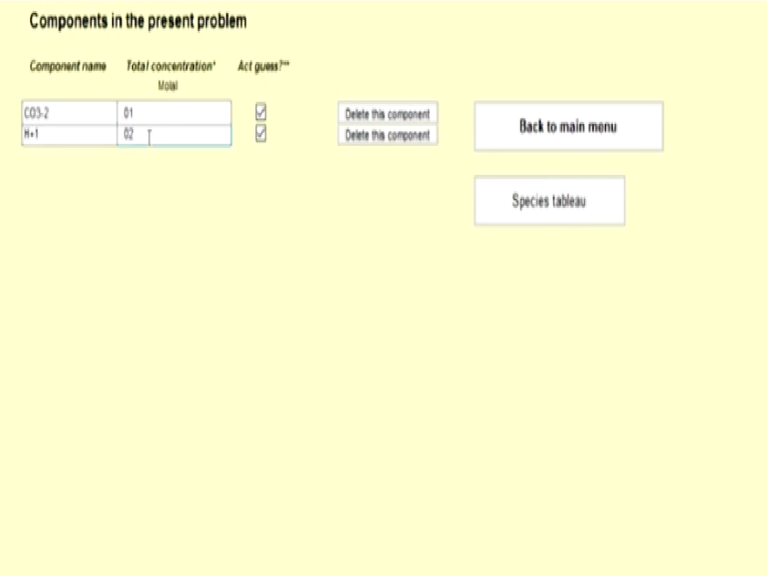

Components in the present problem

Component name	Total concentration* Molal	Act guess?**
CO3-2	01	☑
H+1	02	☑

So obviously CO32- 0.01 molal. So there will be mild level because these are molal units and not molar and H+ is 0.02 so back to main menu. So obviously it is a closer system, so no gas is present in that particular case and now we have particular tab here that says multi problem or sweep.

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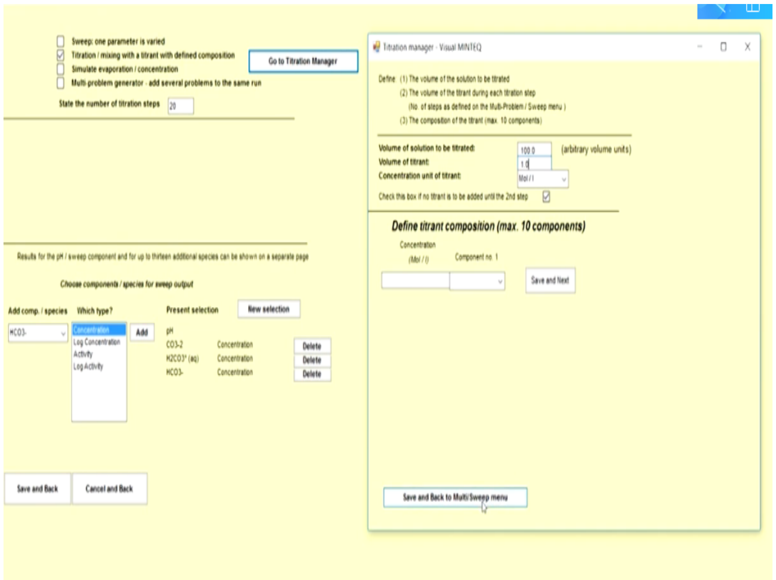

☐ Sweep: one parameter is varied
☑ Titration / mixing with a titrant with defined composition
☐ Simulate evaporation / concentration
☐ Multi-problem generator - add several problems to the same run

State the number of titration steps: 20

Results for the pH / sweep component and for up to thirteen additional species can be shown on a separate page

Choose components / species for sweep output

Add comp. / species: HCO3-

Which type? Concentration / Log Concentration / Activity / Log Activity

Present selection:

pH	
CO3-2	Concentration
H2CO3* (aq)	Concentration
HCO3-	Concentration

Titration manager - Visual MINTEQ

Define: (1) The volume of the solution to be titrated
(2) The volume of the titrant during each titration step
(No. of steps as defined on the Multi-Problem / Sweep menu)
(3) The composition of the titrant (max. 10 components)

Volume of solution to be titrated: 100.0 (arbitrary volume units)
Volume of titrant: 1.0
Concentration unit of titrant: Mol / l
Check this box if no titrant is to be added until the 2nd step ☑

Define titrant composition (max. 10 components)

Concentration (Mol / l) | Component no. 1

So when you come to this particular page, you see that you have sweep titration simulate evaporation or concentration of multi problem generator. So the 2 aspects we are going to look at for now is going to be titration and sweep. So let us look at titration manager it is going to ask you the arbitrary units of the volume, you are titrating arbitrary units.

So let us assume just for the sake of this, I am going to choose hundred let us say and volume of the titrant I am going to choose volume of titrant is going to be first step. So I am going to choose one, so if it is hundred milliliter total solutions in your particular conical flask. So I am going to add one milliliter each time or with each step. So that particular case and then I am going to say we are going to start with step 2.

Because I want to see what the system is before variation of this particular component. So let us say I am going to change the concentration of let us say I am going to add base because it is H2 CO3. I am going to see what is going to happen if I am going to have a base. I am looking for H+ here. Let us say H+ because base I am going to say negative. Let us see how we plug that in negative point.

Let us go with one negative point one. So what does that mean? I am going to add base or you know H + at negative point one means base at P point one concentration total volume of hundred units at one unit each, so save and back to multi sweep menu and it is going to ask for the number of steps.

So for now let us say we are going to look at fifteen step, let us say or twenty step so that means a total of 20 milliliter is going to be added and here you can choose which particular components or compounds you want to have in your output. So I am going to have all the concentrations of the carbonate system and H CO3-, if you want you can look at the log concentration activity and so on.

But now I am only looking at the concentrations of the 3 carbonate system relevant species. So again twenty step and titration manager. So what does this mean now? So they are going to be 100 milliliter, let us say, I am assuming hundred milliliter but let us say hundred units of your volume in the flask and add one unit each time and I believe we saved. So I am not going to go back again H+ - 0.1 concentration. So let us go back to save and back run minteq.

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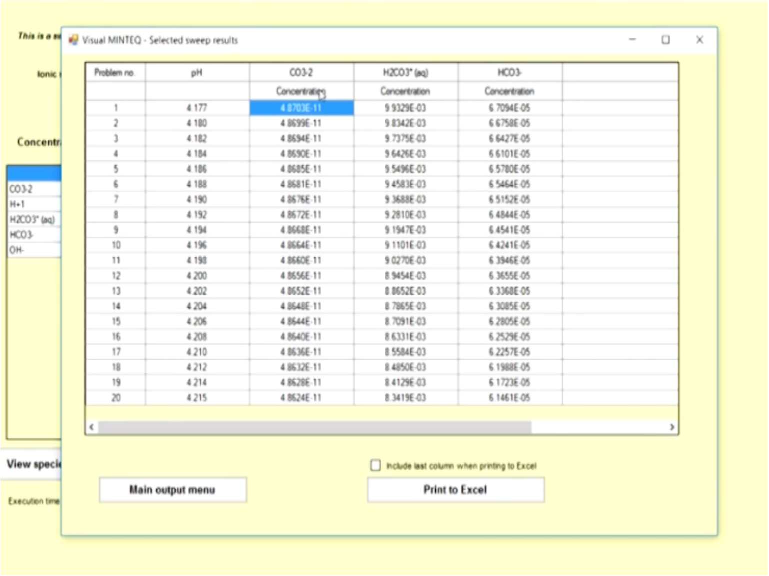

Problem no.	pH	CO3-2	H2CO3* (aq)	HCO3-
		Concentration	Concentration	Concentration
1	4.177	4.8703E-11	9.9329E-03	6.7094E-05
2	4.180	4.8699E-11	9.8342E-03	6.6758E-05
3	4.182	4.8694E-11	9.7375E-03	6.6427E-05
4	4.184	4.8690E-11	9.6426E-03	6.6101E-05
5	4.186	4.8685E-11	9.5496E-03	6.5780E-05
6	4.188	4.8681E-11	9.4583E-03	6.5464E-05
7	4.190	4.8676E-11	9.3688E-03	6.5152E-05
8	4.192	4.8672E-11	9.2810E-03	6.4844E-05
9	4.194	4.8668E-11	9.1947E-03	6.4541E-05
10	4.196	4.8664E-11	9.1101E-03	6.4241E-05
11	4.198	4.8660E-11	9.0270E-03	6.3946E-05
12	4.200	4.8656E-11	8.9454E-03	6.3655E-05
13	4.202	4.8652E-11	8.8652E-03	6.3368E-05
14	4.204	4.8648E-11	8.7865E-03	6.3085E-05
15	4.206	4.8644E-11	8.7091E-03	6.2805E-05
16	4.208	4.8640E-11	8.6331E-03	6.2529E-05
17	4.210	4.8636E-11	8.5584E-03	6.2257E-05
18	4.212	4.8632E-11	8.4850E-03	6.1988E-05
19	4.214	4.8628E-11	8.4129E-03	6.1723E-05
20	4.215	4.8624E-11	8.3419E-03	6.1461E-05

Let us see selected sweep result. So here again I will come back to this main output menu. This is for your particular P1. But you know that we ask these steps to be at 20 equations. When we added H+ at – 0.1 concentration. So we can choose them individually and look at the relevant concentrations or I can obviously just choose the selected sweep results and I am going to have problem 1 to 20 and how the PH changes here and the relevant concentrations.

So obviously because I am adding the base because H + is negative H total is negative. So you see an increase in PH with each problem step and obviously the relevant change in your particular concentrations. The base concentration was less, we are going to change that to the higher concentration and look at what it is going to be? But let us look at what we have here. So the PH is 4.1.

We know that it is much less than the PKA1 of your particular carbonate system which is 6.3. So what would you expect now? You would expect that most of it would be H2 CO3 and H2CO3 and next higher concentration would be HCO3 and the last concentration would be 32-. Again to refresh our memories where did this come? If look at the species, let us say so this is H2CO3 concentration and this is going to be H CO3- concentration and this is going to be CO32 - concentration.

We know that the PKA1 value is 6.3 and I think PKA2 is around 10.3 and our current example has our PH at 4 point. I think 4.1, so just at 4.1 most of it almost all of it is at H2 CO3 where in little particular carbonate concentration is going to be in the form of H CO3- and there is going to be negligible amount of CO32- present at PH 4.1.

Let us switch back at Vminteq and that is what we have here 4.1 and highest concentration is of the most protnate form which is H2CO3 and certain highest concentration. H CO3- and the least would be CO32- and obviously as you keep increasing the PH you are going to see a slight decrease in your H2CO3. But we have not PKA that is the reason, we have not seen a great change. So let us go back to V minteq, I guess, I am going to change the concentration of the particular base that we are adding

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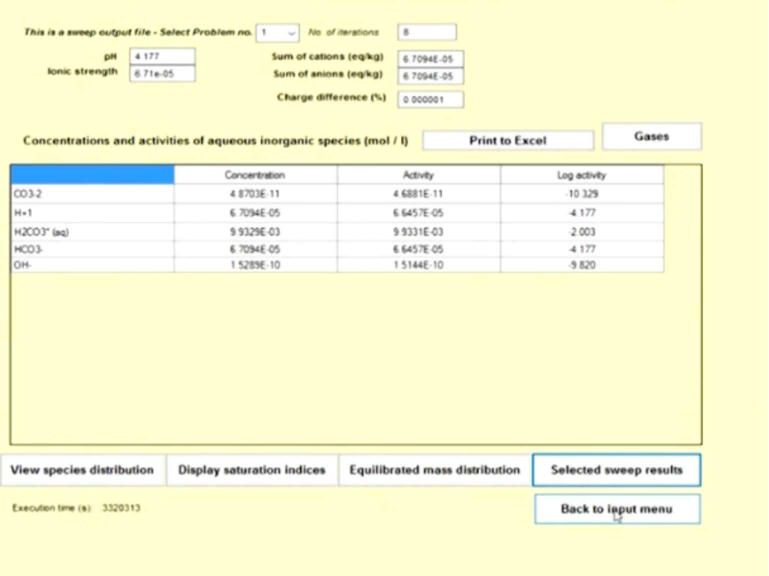

This is a sweep output file - Select Problem no. 1 *No. of iterations* 8

pH 4.177

Ionic strength 6.71e-05

Sum of cations (eq/kg) 6.7094E-05

Sum of anions (eq/kg) 6.7094E-05

Charge difference (%) 0.000001

Concentrations and activities of aqueous inorganic species (mol / l)

	Concentration	Activity	Log activity
CO3-2	4.8703E-11	4.6881E-11	-10.329
H+1	6.7094E-05	6.6457E-05	-4.177
H2CO3* (aq)	9.9329E-03	9.9331E-03	-2.003
HCO3-	6.7094E-05	6.6457E-05	-4.177
OH-	1.5289E-10	1.5144E-10	-9.820

Execution time (s): 3320313

Go to titration manger and I am going to change that here by saying the concentration is much higher. Now let us say, instead of point one I am going to say it is going to be one. Let us say mole per liter and component is going to be H+. Let us look for that concentration H + - 1 mole per liter of H + being added with each unit steps. so save and next I did not add save and next here that could be the reason why we did not see a change here.

So again let us try to do this save and back multi step twenty step titration manager save and back here and I am going to run the minteq and look at the selected sweep result. So that is the reason I guess because I did not save it at have the value. So now we see the jump in PH from 4 P 0.1 to 8.2 with just one particular titration step, I am going to move back to particular input menu and change that again.

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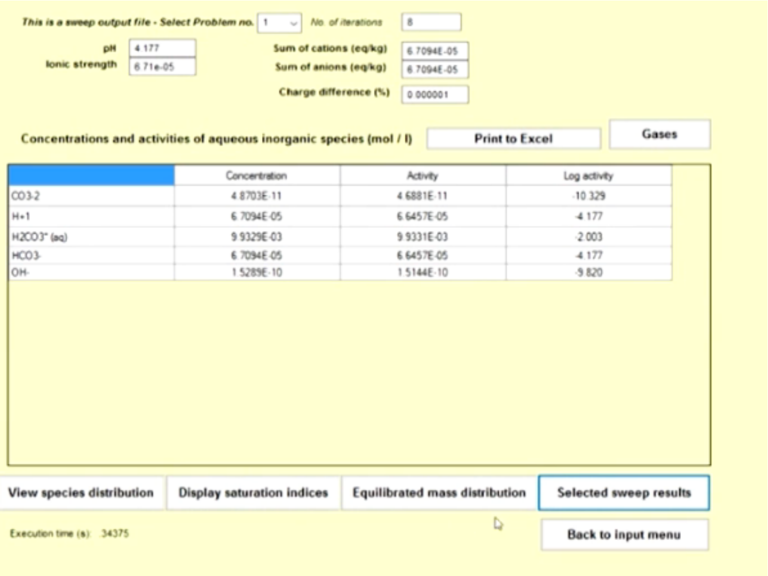

This is a sweep output file - Select Problem no. 1

No. of iterations 8

pH 4.177

Ionic strength 6.71e-05

Sum of cations (eq/kg) 6.7094E-05

Sum of anions (eq/kg) 6.7094E-05

Charge difference (%) 0.000001

Concentrations and activities of aqueous inorganic species (mol / l)

	Concentration	Activity	Log activity
CO3-2	4.8703E-11	4.6881E-11	-10.329
H+1	6.7094E-05	6.6457E-05	-4.177
H2CO3* (aq)	9.9329E-03	9.9331E-03	-2.003
HCO3-	6.7094E-05	6.6457E-05	-4.177
OH-	1.5289E-10	1.5144E-10	-9.820

Execution time (s): 34375

So I am going to delete this I am going to have again 0.01. Let us see, but it is negative value - again h + again save and next and this is what we missed earlier save and back and again everything else is going to be same save and back and run minteq and look at the sweep results. So now we have greater variation now the PH is 4.1 to 5.7. So again but I want to capture the change with respect to PKA which is 6.3. So I am going to again increase the concentration of my particular base here. Let us see, so again back to input menu.

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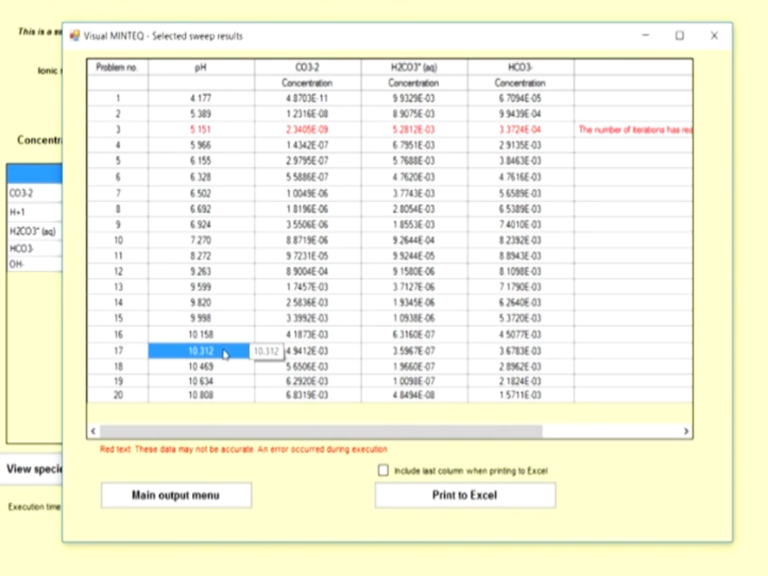

Problem no.	pH	CO3-2	H2CO3* (aq)	HCO3-	
		Concentration	Concentration	Concentration	
1	4.177	4.8703E-11	9.9329E-03	6.7094E-05	
2	5.389	1.2316E-08	8.9075E-03	9.9439E-04	
3	5.151	2.3405E-09	5.2812E-03	3.3724E-04	The number of iterations has rea
4	5.966	1.4342E-07	6.7951E-03	2.9135E-03	
5	6.155	2.9795E-07	5.7688E-03	3.8463E-03	
6	6.328	5.5886E-07	4.7620E-03	4.7616E-03	
7	6.502	1.0049E-06	3.7743E-03	5.6589E-03	
8	6.692	1.8196E-06	2.8054E-03	6.5389E-03	
9	6.924	3.5506E-06	1.8553E-03	7.4010E-03	
10	7.270	8.8719E-06	9.2644E-04	8.2392E-03	
11	8.272	9.7231E-05	9.9244E-05	8.8943E-03	
12	9.263	8.9004E-04	9.1580E-06	8.1098E-03	
13	9.599	1.7457E-03	3.7127E-06	7.1790E-03	
14	9.820	2.5836E-03	1.9345E-06	6.2640E-03	
15	9.998	3.3992E-03	1.0938E-06	5.3720E-03	
16	10.158	4.1873E-03	6.3160E-07	4.5077E-03	
17	10.312	4.9412E-03	3.5967E-07	3.6783E-03	
18	10.469	5.6506E-03	1.9660E-07	2.8962E-03	
19	10.634	6.2920E-03	1.0098E-07	2.1824E-03	
20	10.808	6.8319E-03	4.8494E-08	1.5711E-03	

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☐ Include last column when printing to Excel

Titration manager, so instead of point zero one let me take up 10 times and here the key is – 0.1. What are we trying to have here? We are going to trying to have H+ save and next, so again what does this mean? So with each unit step I am adding with each titration step. I am adding base of point one mole per liter and obviously H total will reflect that in -0.1 and how many units of the particular volume of your solution in your conical flask and total number of steps is 20.

So total of twenty milliliter is been added so save and back and hopefully now we should have the relevant results. Now we have the relevant results, so we have a change from 4.1 to 10.8 and we should be able to capture all this results here. So let us look at the change here. So four point one as you expect everything will be in the form of H2CO3. So 9.9 into 10 power -3.

So what did that mean? It is almost equal to 10 power -3 or initial concentration of CO3 total was 10 power -2 and you see H2CO2 aqueous itself nine point nine into 10 power - 3. But as we reached the PKA value around 6.3 which is at the step titration step number 2, you see that the concentration. What is it now? H2CO3 and H CO3- are the same and that is what we know from our background at PKA.

One the relevant protnate and deprotnate form are going to be the same in concentration and let us move on to 10 point 3 which is the second particular PKA 2 and at that particular case H 2 CO3 will be nonexis10t more or less and that is what you see here and now or less everything will be in the form of CO 3 2 - and H CO 3 - and that is what you see here at the PKA 2 its four point nine into 10 point - and 3 point 6 into 10 to the power - 3.

Let us look at the figure and see what this means? So 4.1 everything is in the form of H 2 CO 3 and at 6.3. We see that it is equal amount of H 2 CO 3 and H C C CO 3 - and at around 10.3 it is going to be equal amounts of H CO 3 - and CO 3 2 - and that is what we just looked at, but one issue with what we just did is that you know we considered the total volume units to be 100.

At the end of twentieth step we added 20 units now for example, to make it easier let us assume, that we have 100 milliliter initially and I am adding one milliliters at each titration step. So the end of my titration let us say I have a total volume of 120 milliliters. So the issue with setting up the titration in such a way is that you know your particular total concentration are going to change.

Because of considerable addition of your volume of your titrant where we had 100 milliliters, we now have 120 milliliters. So let us look at the way to get out of this particular scenario. So may I now put menu I am going to say switch come back to here back to input menu. So again how do we do that?

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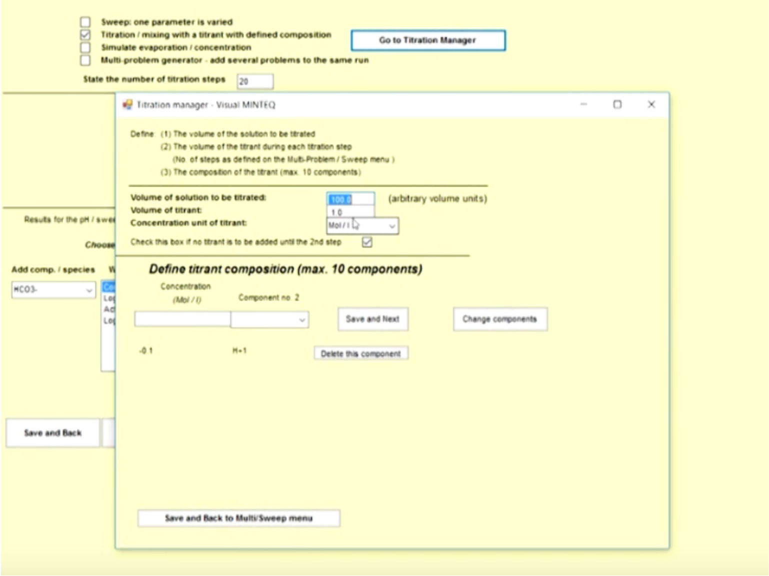

☐ Sweep: one parameter is varied
☑ Titration / mixing with a titrant with defined composition
☐ Simulate evaporation / concentration
☐ Multi-problem generator - add several problems to the same run

State the number of titration steps: 20

Titration manager - Visual MINTEQ

Define: (1) The volume of the solution to be titrated
(2) The volume of the titrant during each titration step
(No. of steps as defined on the Multi-Problem / Sweep menu)
(3) The composition of the titrant (max. 10 components)

Volume of solution to be titrated: 100.0 (arbitrary volume units)
Volume of titrant: 1.0
Concentration unit of titrant: Mol / l
Check this box if no titrant is to be added until the 2nd step ☑

Define titrant composition (max. 10 components)

Concentration (Mol / l) | Component no. 2
-0.1 | H+1

So go to titration manager, so we are going to say that you know we just want to look at the change in PH here. They are on the way but with respect to titration what can you do? You can say that the concentration of your particular titrant is very high or you can show that or you can choose that the initial volume of your particular solution is very high. So instead of 100 I can have 10,000, these are all arbitrary units. I can have very high concentration of my particular base.

Let us say instead of hundred I am going to go up with 10,000 and obviously because I am increasing that I also need to increase the concentration of my particular acid. I am going to say it is going to be equal to - 1 and it is again going to be H +. So again what does this mean ? Now I am adding acid at high concentration at each step. But because the total volume is 10 thousand units and I am only adding 20 times of one unit 10,000 and 20 does not make much difference compared to 10 thousand.

So this is the better way when you are trying to look at the change with respect to PH when you are using the titration tab. Why is that again? Otherwise you are going to see to it that the concentration of your particular component or species are going to change your titrant volume is going to be equal to what you are titrating against.

So that is one particular way, so we will not go through that again for lack of time. But there is another aspect we would like to demonstrate here that is that we have sweep. So this is not more complex but for titrations we can use that. So what is sweep? It means that one parameter is varied sweep, so we have eh and potential and so on which we are not going to look at or you can change the total concentration of any component.

So what is the additional functionality that you have here with respect to current state to titration? Let us see you know you have one parameter that is varied but when titration, let us say earlier we had only H + but if I wanted to I can also have calcium, magnesium or any such parameters or components mentioned in the titration tab. But here it is much easier if I am just looking at the change with respect to PH.

But again with respect to titration it is always better if it is complex system to look at titration relevant chart as in you know you go to titration here, go to titration manager. So earlier it was only H +, so that was fine but let us if had calcium then I can do from this particular tab here. I am titrating your particular solution with against calcium.

I have some particular solution here which I want to form complex or precipitate and I am titrating with calcium let us say, obviously I cannot use this sweep menu I only need to use the titration menu. But obviously if I am just looking at the change in PH I can go to the sweep menu which is we are going to use and further analyze our system.

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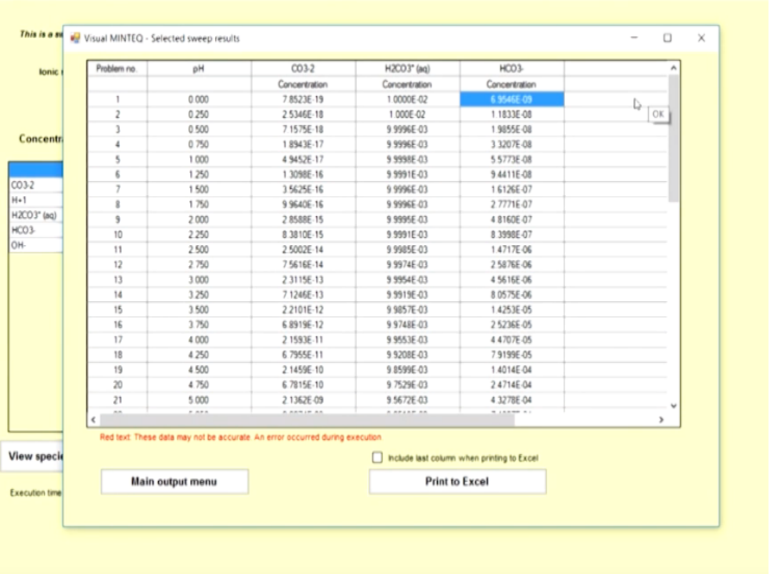

Problem no.	pH	CO3-2	H2CO3* (aq)	HCO3-
		Concentration	Concentration	Concentration
1	0.000	7.8523E-19	1.0000E-02	6.9546E-09
2	0.250	2.5346E-18	1.000E-02	1.1833E-08
3	0.500	7.1575E-18	9.9996E-03	1.9855E-08
4	0.750	1.8943E-17	9.9996E-03	3.3207E-08
5	1.000	4.9452E-17	9.9998E-03	5.5773E-08
6	1.250	1.3098E-16	9.9991E-03	9.4411E-08
7	1.500	3.5625E-16	9.9996E-03	1.6126E-07
8	1.750	9.9640E-16	9.9996E-03	2.7771E-07
9	2.000	2.8588E-15	9.9995E-03	4.8160E-07
10	2.250	8.3810E-15	9.9991E-03	8.3998E-07
11	2.500	2.5002E-14	9.9985E-03	1.4717E-06
12	2.750	7.5616E-14	9.9974E-03	2.5876E-06
13	3.000	2.3115E-13	9.9954E-03	4.5616E-06
14	3.250	7.1246E-13	9.9919E-03	8.0575E-06
15	3.500	2.2101E-12	9.9857E-03	1.4253E-05
16	3.750	6.8919E-12	9.9748E-03	2.5236E-05
17	4.000	2.1593E-11	9.9553E-03	4.4707E-05
18	4.250	6.7955E-11	9.9208E-03	7.9199E-05
19	4.500	2.1459E-10	9.8599E-03	1.4014E-04
20	4.750	6.7815E-10	9.7529E-03	2.4714E-04
21	5.000	2.1362E-09	9.5672E-03	4.3278E-04

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So I am going to say that the PH is going to change and let us say the start value it is going to I am going to look at the change from PH0 and let us say the increment between values. Let us say I will go with 0.5 or 0.25, let us say 0.25 and if I want to go to fourteen and if it is fourteen times 2 28 56 and I will go with 54 then 54.

So the start value and the increment between value. So obviously you need to be able to approximate I am going to go with 14 hopefully 54 should satisfy my particular case here. So PH starts from zero increment between each particular step is 00.25 point five and so on that is what this means and how many titrations 54 I guess and same case as earlier PH co 3 2 - and so on.

This is what I want to look at so save and back. Let me just confirm my component, so we have 0.01 and 02 of my H + H 2 CO 3 and now we are going to run minteq again. You can look at the number of titration upto 54 here and initial PH that I wanted was PH zero. Let us see what the final PH was if my calculations were 13.25. So I should have had 3 more titrations same way we will look at the selected sweep results here.

So selected sweep result now with PH, I can clearly see how the concentration have is changing with PH0. Obviously everything will be in the form of H 2 CO 3 and nothing else of CO 3 2 - or H CO 3 - and that is what you see so again too much data in a tabular form, you can never understand what is happening. So obviously I want to be able to visualize it in a better manner.

So I am going to you know come with a graph here. So how do I do that here I have the option for into excel.

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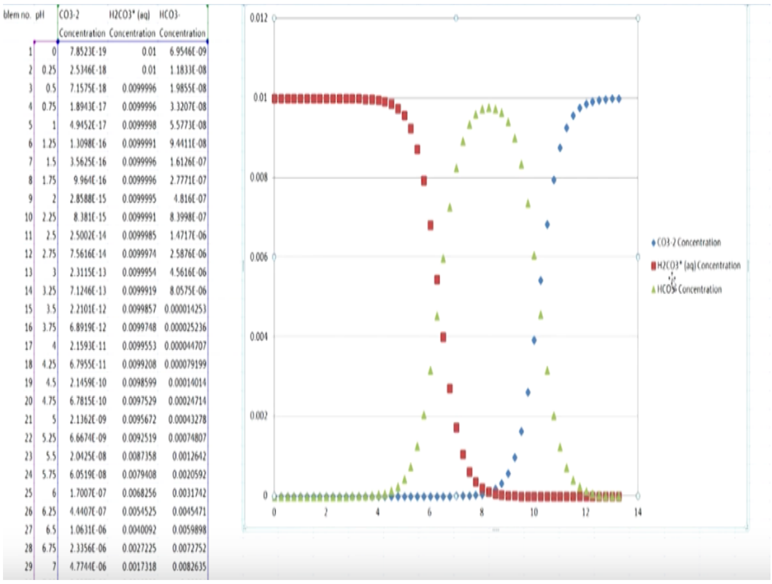

blem no.	pH	CO3-2 Concentration	H2CO3* (aq) Concentration	HCO3- Concentration
1	0	7.8523E-19	0.01	6.9546E-09
2	0.25	2.5346E-18	0.01	1.1833E-08
3	0.5	7.1575E-18	0.0099996	1.9855E-08
4	0.75	1.8943E-17	0.0099996	3.3207E-08
5	1	4.9452E-17	0.0099998	5.5773E-08
6	1.25	1.3098E-16	0.0099991	9.4411E-08
7	1.5	3.5625E-16	0.0099996	1.6126E-07
8	1.75	9.964E-16	0.0099996	2.7771E-07
9	2	2.8588E-15	0.0099995	4.816E-07
10	2.25	8.381E-15	0.0099991	8.3998E-07
11	2.5	2.5002E-14	0.0099985	1.4717E-06
12	2.75	7.5616E-14	0.0099974	2.5876E-06
13	3	2.3115E-13	0.0099954	4.5616E-06
14	3.25	7.1246E-13	0.0099919	8.0575E-06
15	3.5	2.2101E-12	0.0099857	0.000014253
16	3.75	6.8919E-12	0.0099748	0.000025236
17	4	2.1593E-11	0.0099553	0.000044707
18	4.25	6.7955E-11	0.0099208	0.000079199
19	4.5	2.1459E-10	0.0098599	0.00014014
20	4.75	6.7815E-10	0.0097529	0.00024714
21	5	2.1362E-09	0.0095672	0.00043278
22	5.25	6.6674E-09	0.0092519	0.00074807
23	5.5	2.0425E-08	0.0087358	0.0012642
24	5.75	6.0519E-08	0.0079408	0.0020592
25	6	1.7007E-07	0.0068256	0.0031742
26	6.25	4.4407E-07	0.0054525	0.0045471
27	6.5	1.0631E-06	0.0040092	0.0059898
28	6.75	2.3356E-06	0.0027225	0.0072752
29	7	4.7744E-06	0.0017318	0.0082635

Thus automatically transfer the relevant data to excel. Let it come through, so here we have PH3. 13.25 starting from PH0. So let us try to get the relevant graphs here. So I am going to look at scatter plot from now and I am going to say select data and chart range is going to be equal to this particular set here and I am going to have let us see if CO 3 2 - H CO 3 and so on.

So I am on the track and so this is what I have here. So what do we observe here? Please keep in mind that this is just the scatter plot. The actual data points with plotted here. So the X axis is the PH0 to 13.25 or 0 to 14 here and Y axis is the concentration. So obviously if you remember the initial concentration of H 2 CO 3 that we put in was 0.01 molar.

So the obvious the maximum concentration of any of the species can only be 0.01 and now we see with our titration how the species change everything is in the form of H 2 CO 3 is the red here. H 2 CO 3 but as we reach the PKA value around 6 point 3. We see that there is a drastic drop in H 2 CO 3 concentration and drastic increase in H CO 3 - concentration and PKA one which is 6.3 or there about we see that H 2 CO 3 and H CO 3 - concentration are equal.

As we keep increasing the eight I see that almost everything is in the form of only H CO 3 - and there is no little to no concentration of CO 3 2 - and H 2 CO 3 and as I keep increasing the PH. What is happening now? H CO 3 is decreasing while now CO 3 2 - is increasing at PKA 2. We know is 10.3 for the carbonate system is that we end up with this particular graph.

You know scenario where in CO 3 2 - H CO 3 - concentration are now equal here and as I keep increasing the PH or titrating it further such that the PH increases, what do I see? We see that CO 3 2 - starts predominating and there is little to no H CO 3 - present beyond PH12. So what did this tell you now? So here if I am trying to titrate and look at the species of the various equilibrium carbonate species there is 2 equivalence point.

So what does that mean now? Because H 2 CO 3 can donate 2 particular protons. So here in this particular system I have 2 equivalence point and when are they going to be obviously at around the PKA values depending obviously on the total CO 3 total present too. Again you can calculate the equivalence point depending upon the relevant formula. We will calculate in the last session again of it is again diprotic acid or will have 2 particular equivalence point monoprotic as in acetic acid it would have one particular equivalence point.

So this is something that we demonstrate now. So now we are going to move on to buffers. So what is the point of having acids and base? Now let us see and you know where you would use them practically, I guess that many applications but let us say I have particular experiment and I want to maintain the PH at the particular value.

Obviously I cannot maintain at exact let us say if I am looking for 6.5 I cannot always see to it that it only changes stays at 6.5 but I am okay with it being + or - point 2 change. So let us see what I am referring to here.

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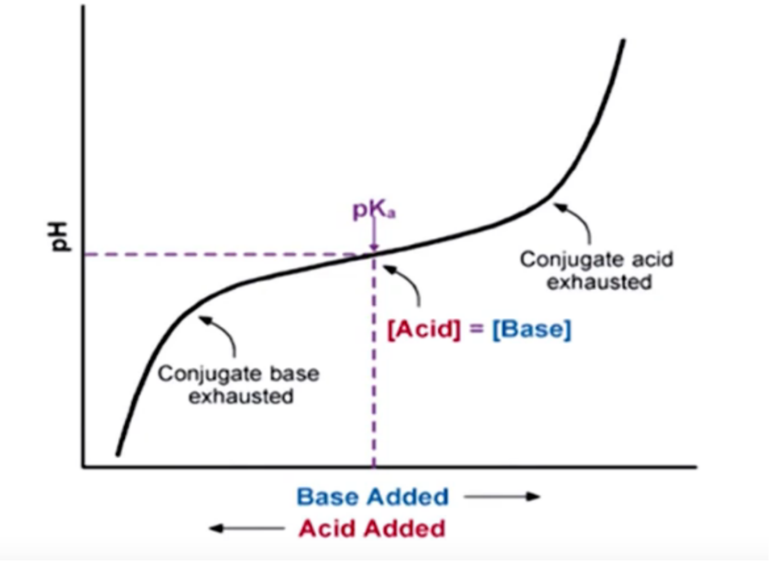

I guess again just a particular schematic ideas here with respect to our titration. So the PH as the base is added, we have the change from base here at the PKA and so on conjugate acid get exhausted. So this is more or less description or you know graph that is relevant to what we just discussed. I am going to not skip this in detail obviously at the PKA value the relevant conjugate acid and base are going to be at the same concentration again add the acid PH is going to decrease and the reverse phenomena is going to be visible, so again I am going to move on.

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Buffers

Natural

Alkanity

Engineered

pH

6.5

6.5 + 0.5

Acid

So we are going to discuss buffers and you know that in the natural systems, we have relevant applications and also in the engineered systems. So natural system we typically look at alkalinity and we will discuss this particular important aspect later on. But let us say for now we are going to consider a particular scenario where we have particular PH or I want to maintain the PH of the system at PH 6.5 and let us say the system can produce from acid.

Let us say or during the course of the experiment acid can be produced and you know it can bring down the PH but I do not want my PH to go beyond let us say 6.5 + or – 0.5. I am okay with PH staying between 6 and 7 but no further thing so what do I do? I know or we are going to try to correlate with what happens in the natural systems too.

But let us try to understand this so an acid can be produced in my experiment or base can be produced and it can affect the PH. But let us say I only want the PH to be at particular value because let us say I am concerned with this kinetic let us say I am going to add an buffer and what is this buffer or what is the role of this buffer what is the objective here? I do not want the PH to change drastically even if there is any acid or base produced.

The key here is that any acid or base is produced the buffer should be able to eliminate the change in PH. So what does that mean now? So it means that whenever we add you know change in H total means it can it includes the addition of either an acid or a base. So whenever there is a change in H total the buffer will see to it that the change in PH is relatively minimal, that is what my function you know that is what I expect from a buffer. Let us see what it is about again, so here I have a graph, so here I have

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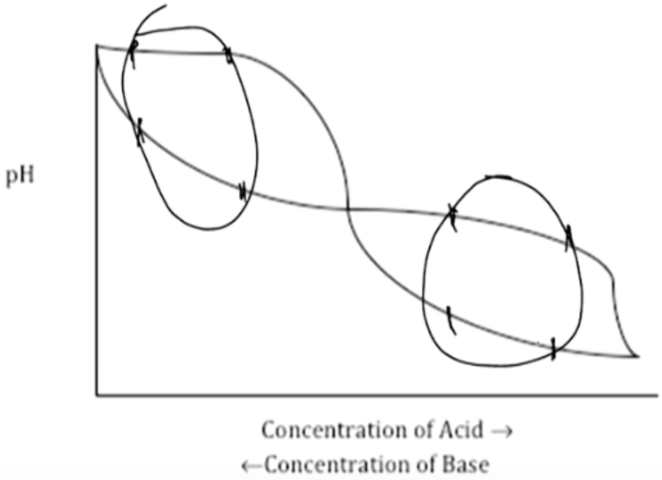

A graph and I have PH on the Y axis and let us say I am adding acid as I go from left and I am adding a base as I am going from left. So obviously as I am adding an acid what is happening to the PH here? So this is the system here, so assume that this is the case when the PH I am adding that acid and this is the case when I am adding the base.

You know hypothetical example here, so let us say when I asked student to choose you know in which region. Let us say is the particular system well buffered. So please take some seconds or few minutes I guess not minutes anyway seconds I guess to identify those regions in this particular system when the system is well buffered again keep in mind that the key is that PH is to change less with when acid or base is added.

So identify those region when the PH or DPH with addition of H + it is going to be less. So people though you know typically because they are drawn to you know the mid section here. People identify this particular region as saying that it is well buffered. But let us say you know we mentioned this will be changed in ways.

So here let us look at this one. Let me erase this one and come back to the ideal case. So here if I am saying that as concentration of base is added this is the change and let us say the hypothetical example was this is the change in PH and I am (()) (27:06) that can be taken into account. So anyway base added with let us say there is not a huge lot of change in PH. So I am adding the base, so the PH concentration is increasing.

I am increasing the concentration of base, the PH is increasing here. So here let us say this particular region there is less change in PH when considerable base is added that is fine. You might think that this is well buffered but if I look at the reverse case the acid is added and the PH is decreasing and same region, let us say for the same case of the acid being added. We see that in this particular region even a small concentration of acid added the change in PH is considerable.

So what does this mean? Now this it means that in this region the system is not well buffered. So let us try to highlight those particular aspects. So they are these regions if I look at these regions, so even with addition of acid or base the change in PH is relatively minimal in this particular region. So again keep in mind that we are talking about change in PH in your due to addition of either acid or the base and not just to due to just acid or base.

So again it needs to be able to resist the changes in PH in both directions and not just in one direction that is the crust of the matter. So in the next session we are going to try to develop an equation for calculating this buffer in in10sity and then may be looking at few applications on V minteq. I guess with that I will end this session and thank you.