Elementary Electrochemistry

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Numerical Problems on Faraday's Laws of Electrolysis

Hello everyone. Welcome back to the course entitled Elementary Electrochemistry. In the previous class we have discussed about one reversible cell, the Daniell cell and then we talked about the Castner–Kellner process which is the industrial preparation of sodium hydroxide. So, with the knowledge that we have gained in last few lectures we would be able to solve a few problems that I am going to discuss now.

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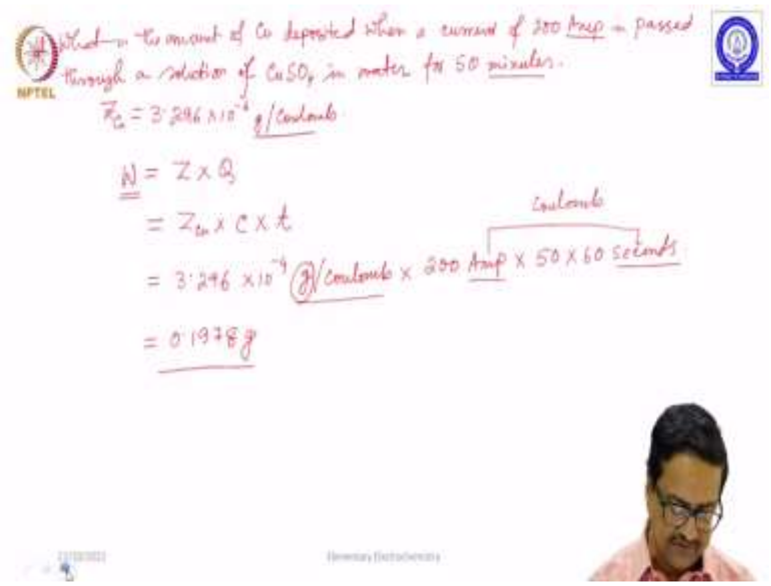

I am writing down the first problem for you. What is the amount of copper deposited when a current of 200 ampere is passed through a solution of copper sulfate in water for 50 minutes. Given is that the electrochemical equivalent Z for copper is 3.296 into 10 to the power minus 4 grams per coulomb. So, what we know from Faraday's first law that W is equal to the electrochemical equivalent Z into the amount of electricity passed cube.

So, in this particular case it should be the Z cu and Q is nothing but the amount of current passed in amperes and time in second. So, we are having the value of Z 3.296 into 10 to the power minus 4 gram per coulomb into current is 200 amperes into 50 minutes which is nothing, but 50 into 60 seconds. So, what I want to highlight or emphasize here is the writing of the correct units against the corresponding physical quantities.

See when you are using physical chemistry and trying to calculate some physical quantity which may or may not have units at the end, but when you are calculating those physical quantities you are using some other physical quantities and if those quantities have some units which are also given in the problem you should use those units while doing the calculations.

And make sure that the unit of the physical quantity that is getting determined is matching with what units you are using. So, now when you do this simple multiplication you end up with a number 0.1978, the question is whether it is gram, kilogram, milligram, centigram what is it? See, here the Z has unit gram, this is ampere second per coulomb and we know that ampere into second is coulomb.

So, we have coulomb in the numerator and per coulomb in the denominator. So, the unit coulomb is removed and the unit gram stays. So, the answer is 0.1978 gram. See this problem is very simple and I know 100 percent that all of you would be able to solve this problem, but what we need to know is that how to use the unit correctly to arrive at the correct unit for the final physical quantity.

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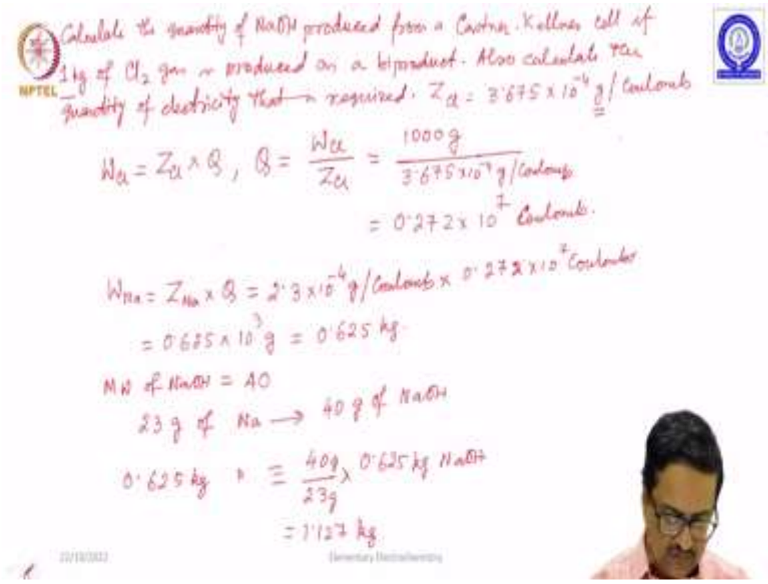

The second question I would like you to try or think about is related to that Castner–Kellner cell which we discussed in the previous class.

Calculate the quantity of NaOH produced from a Castner–Kellner cell if 1 kg of chlorine gas is produced as a biproduct. Also calculate the quantity of electricity that is required. So, for this we have a couple of values given that is Z for chlorine which is 3.675 into 10 to the power minus 4 gram per coulomb from that one has to find out what is the amount of electricity and then from that one can find out what is the amount of sodium that is produced.

So, using Faraday's laws of electrolysis one can easily write W cl is equal to Z cl into Q that is the quantity of electricity used and then Q is equal to nothing, but W cl by Z cl. So, what is W cl weight of chlorine it is 1 kg. So, as soon as you see that it is 1 kg and Z is given in gram so we should write it as 1,000 grams divided by the corresponding Z that is 3.675 into 10 to the power minus 4 gram per coulomb.

This is equal to 0.272 into 10 to the power minus 4 coulomb. So, then when we try to calculate the W sodium it is nothing but Z sodium into Q and we need to find out this value of Z sodium from the electrochemical tables available in various textbooks. So, this Z sodium is 2.3 into 10 to the power minus 4 gram per coulomb multiplied by 0.272 into 10 to the power minus sorry this is not 10 to the power minus 4, I think this is 10 to the power 7 coulombs.

So, when you do this multiplication you will get the number as 0.625 into 10 cube gram which essentially means 0.625 kilogram of sodium that will be produced when 1 kg of chlorine gas is produced at the anode chamber. Remember, that there are two anode chambers so this is the overall amount of chlorine gas produced at the two chambers.

So, now we know the molecular weight of NaOH is nothing but molar mass is 40 grams per mole. So, 23 grams of sodium corresponds to 40 grams of NaOH then 0.625 kg of sodium will correspond to 40 by 23 both are in gram. So, gram gets cancelled and 0.625 kg of NaOH which is equal to 1.127 kg of sodium hydroxide that will be produced when 1 kg of chlorine gas is released at the anode chambers.

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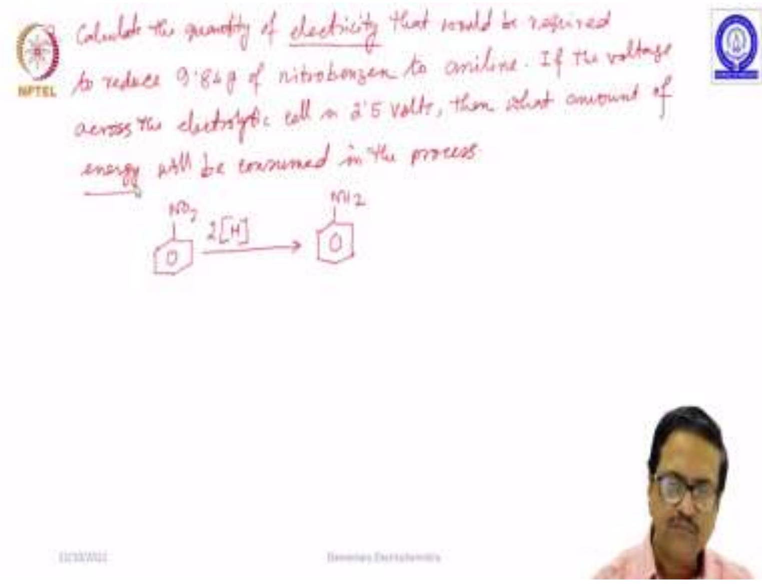

So, from here we would like to move to the third problem which I would like to leave it for you to try to solve. Calculate the quantity of electricity that would be required to reduce 9.84 gram of nitrobenzene to aniline and then find out if the voltage across the electrolytic cell is 2.5 volts then what amount of energy will be consumed in the process. So, just one hint that this is how one should think about.

You are doing a reduction of nitrobenzene to aniline through an electrochemical process where to do this reduction we will need two units of hydrogen atoms. So, one has to consider how to produce two units of hydrogen atoms by an electrochemical process and then from that you can consult electrochemical standard textbooks where you will get some electrochemical equivalence if required and from that you should be able to calculate the quantity of electricity that is in terms of coulomb and what is the energy that is in terms of watt.

So, I would like to stop this lecture here and we will continue from here in the next class. Thank you.