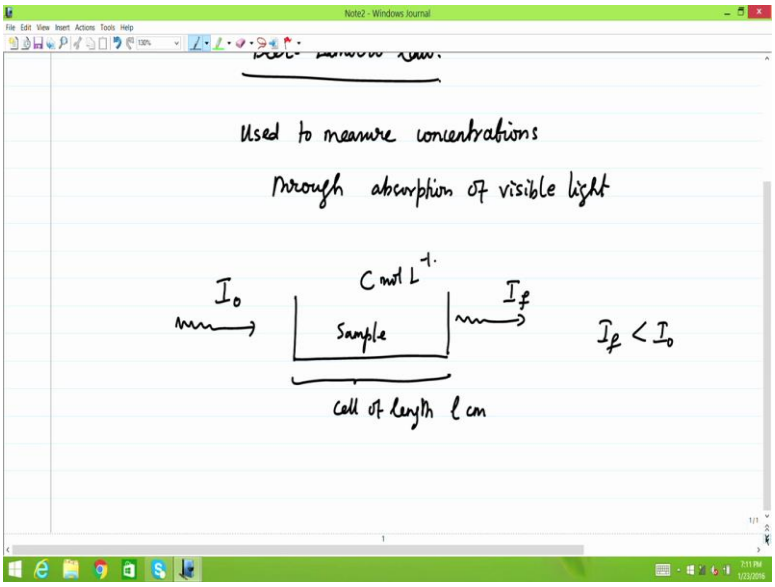
Chemistry II: Introduction to Molecular Spectroscopy
Prof. Mangala Sunder
Department of Chemistry and Biochemistry
Indian Institute of Technology, Madras

Lecture No – 09
Beer – Lambert Law

Welcome back to the lecture on spectroscopy the introduction to molecular spectroscopy again chemistry 2 this is a very short lecture on an important quantitative law known as the Beer Lambert Law, which is used to study the florescent properties and also determine concentrations of compounds, which show florescent characteristics in samples.

(Refer Slide time: 00:44)



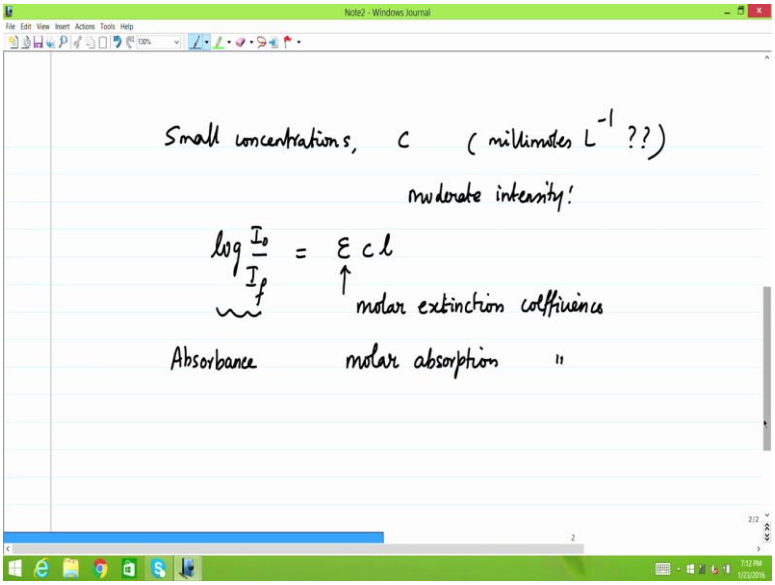
Therefore, it is a quantitative law used to measure concentrations of species through florescent basically, absorption of visible light. And I shall just write down the law in a simple form we will see more of it when we study electronics spectroscopy with some applications and properties of molecules and so on.

In a very simple and elementary form the Beer Lambert Law goes like this suppose we have light falling on a sample tube containing the sample and let the concentration be C

moles per liter and let the length of the spectroscopic cell the Photom the spectro photometer the cell with which we use to measure the absorption and also take the spectrum this is the cell of the length.

So, L centimeters so, you fully 1 centimeter or even less than that and if light with a certain initial intensity I not visible light falls on the sample and light with the intensity I F is emitter obviously, I F is less than I not that means, the sample has absorbed some light and this phenomenon.

(Refer Slide time: 02:35)

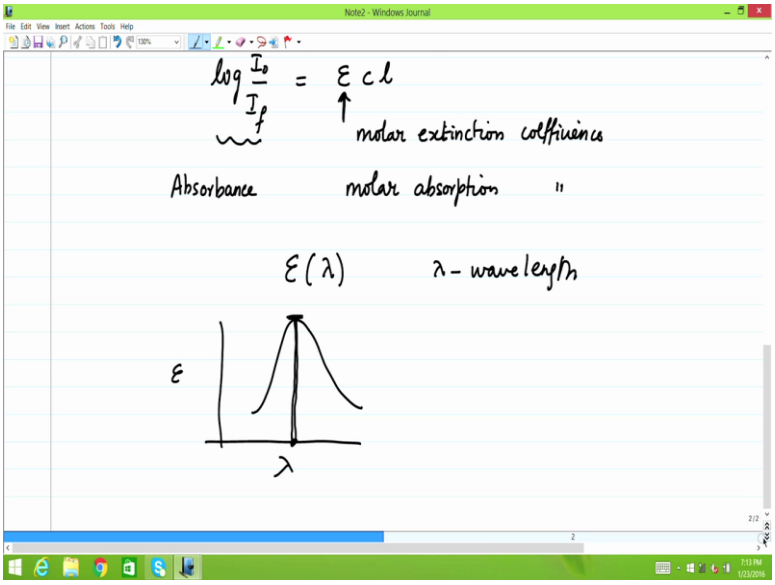


For certain small concentrations and reasonably low intensity of light absorptions small concentrations C like millimoles per liter kind of concentrations or even less typical example ok.

And then for light of moderate intensity satisfies the law that log I not by I F is equal to a constant times the concentration of the substance and is the length of the cell and this constant is called molar extension coefficient or molar absorption coefficient and this is called absorbents.

You can also write this in the form of transmitter's radiation and so this can be written in the form of light that is this is the light that is transmitted therefore, this ratio the log rhythm of I not by I F gives a constant associated with each system each chemical species.

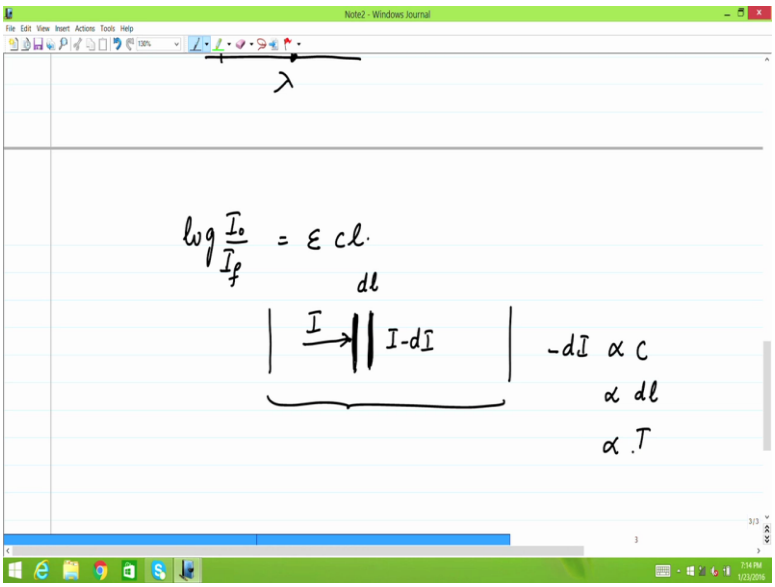
(Refer Slide time: 04:08)



One important thing is that this epsilon is actually a function of the wavelength of light lambda being the wavelength. So, typically if a species absorbs light as a function of the lambda and you write the epsilon as a function of epsilon lambda you choose that value of epsilon for which the absorption is maximum that is that value of the light lambda.

So, you choose that lambda and perform this experiment and these are tabulated in all electronic spectra text books and also in analytical chemistry text books.

(Refer Slide time: 04:52)

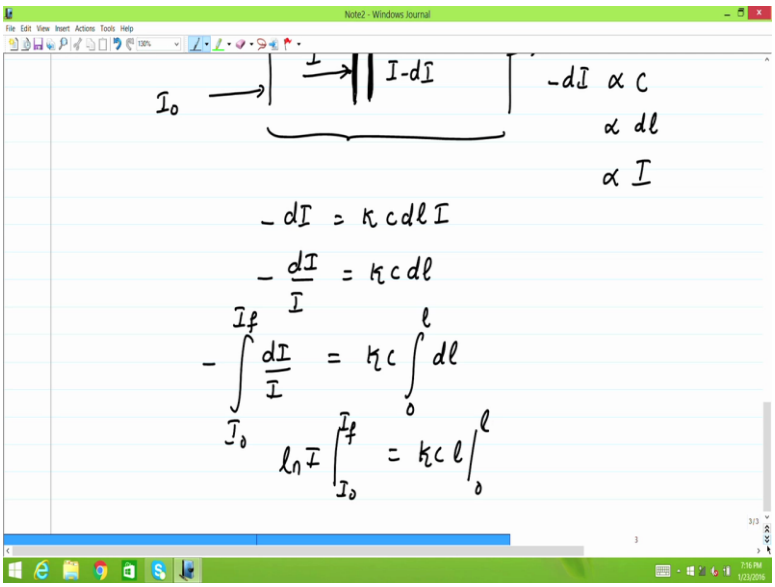


Now, how do we get this law log I not by I F is equal to this constant long time concentration and length. So, very simple argument that if you have a cell of length L consider a small an extremely small what is known as infinite simile small DL because at that level you can imagine that most of the things will be linear.

If there is an absorption that absorption will be roughly proportional to the concentration in that region and the absorption I mean if there is more species obviously, there will be more absorption that linear law can be obtained from starting with this kind of infinite terminals.

Therefore if you do that the DL which is also a very small length tells you that the absorption is dependent on DL itself if DL is slightly more absorption. So, so what you do is you take the differential if I is the intensity at this point and I minus DI is the intensity of light that is emitted passing through DL then you can write the minus DI as roughly proportional to the concentration and proportional to the DL and obviously also proportional to the intensity of light that falls on it therefore, if you write this.

(Refer Slide time: 06:21)

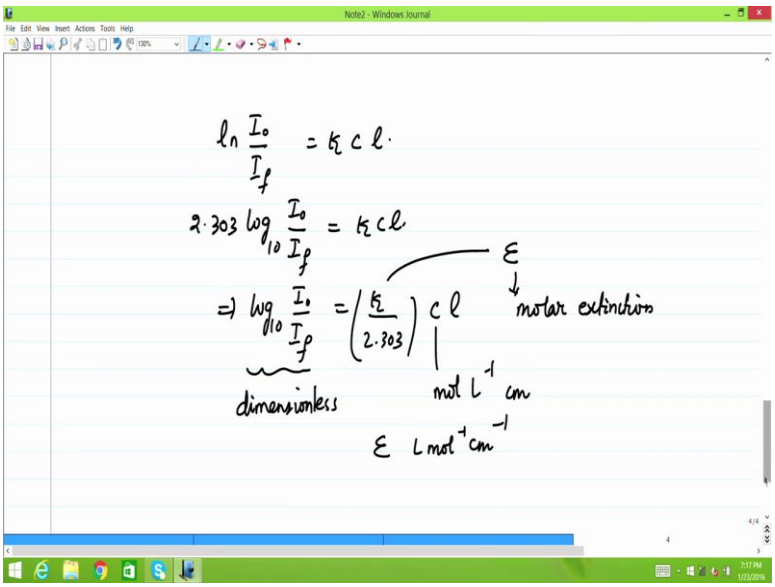


The linear law simply gives you minus DI is some constant which I will write as say kappa K some K times C times DL times I and, you can write by this DI by I is a kappa constant CDL.

And now you extend this argument and this is what happens throughout and therefore, if you start with I not here as the initial intensity and in the end of it I F as the intensity of light emitted at the other side of the cell then you know when you integrate this equation you integrate between the limits I not and I F and write DI by I and write that as the length being also integrated as kappa times CDL starting from the length 0 here to the length L.

So, this gives you immediately LNI between the limits I not and I F is kappa CL between the limits 0 and L.

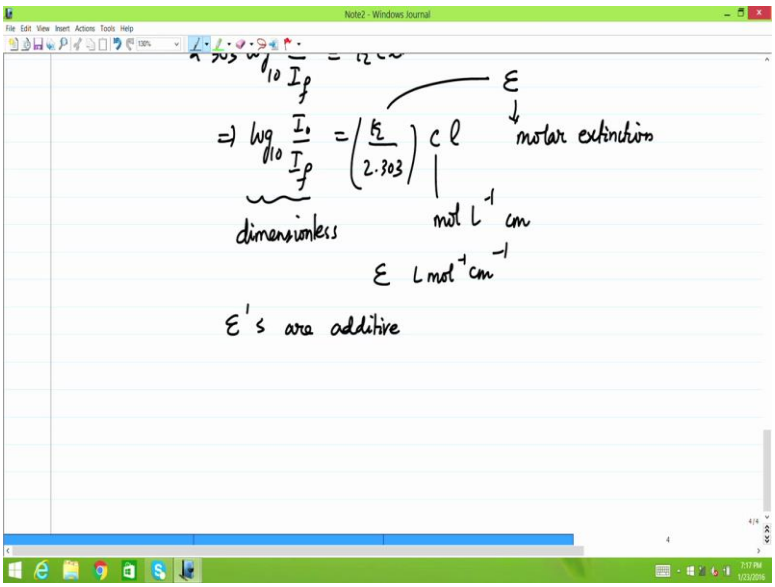
(Refer Slide time: 07:35)



And therefore, you know immediately you get LNI not by I F is kappa times C times L and LN is of course, 2 point 3 not 3 times log rhythm to the base 10 of I not by I F. And that is equal to kappa times CL and so you write log rhythm of to the base 10 I not by I F is equal to kappa by 2 point 3 naught 3.

Which is again a constant times CL and this is what is called epsilon or the molar extension coefficient. And by dimension please remember this is dimension less because they both refer to intensities this is right left hand side is dimension less right hand side is moles per liter. And usually L is extressed in centimeter therefore, epsilon is liter per mole per centimeter and at low concentrations and low intensity epsilons are additives.

(Refer Slide time: 08:41)



So, if you have 2 substances that differ in concentrations then the absorption at that frequency of or the wavelength of light by both these substances is roughly additive that the absorbents of the first one and the absorbents of the second one.

And in the law given ratio and here they add in terms of the concentration times the molar extension coefficient some small numerical problems will give you how to do this in a (Refer Time: 09:14) and how to do this for different concentrations and also sometimes determine the unknown concentration of the substances that you want to find out in by a florescent experiment.

This is an important tool and we shall see more of it, but I just wanted to introduce this as to something to remember before we do the electronic spectroscopy. From the next lecture on wards we shall start with the microwave and then the vibrational and the electronics spectroscopy and also talk about the molecular properties like the dipole movement nepolarisability the movements of inertia as we start to looking at microwave spectroscopy.

There will be some numerical problems given on this in some of your assignments to make you familiar with some of these elementary concepts will continue these

elementary concepts will continue this with the subsequent lectures on rotational spectroscopy until then.

Thank you very much.