Course on Analytical Chemistry
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Module No 01
Lecture 02: Methods

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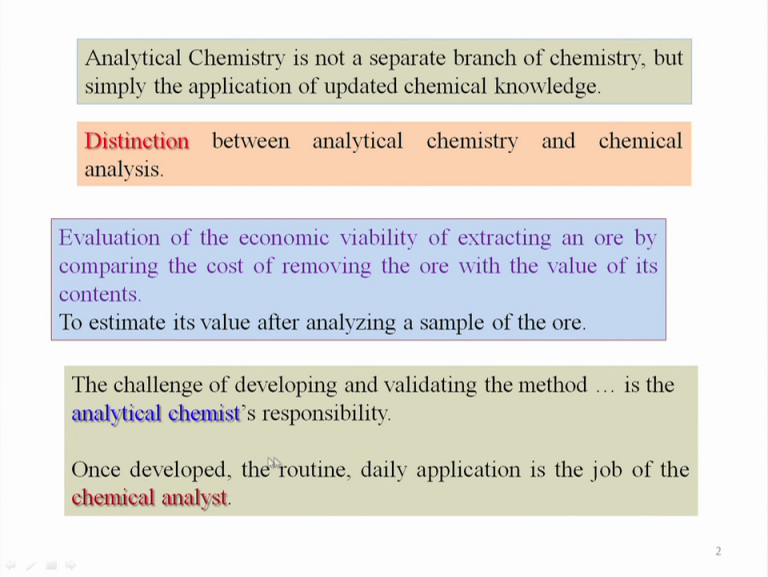

Welcome to this class analytical chemistry where we were discussing about how important is the analytical chemistry to all other subjects where we see that article chemistry is not a separate branch of chemistry but it is simply an application because once we have a very good knowledge about the analytical chemistry we can apply to this particular branch, to all other sciences, because this application of any updated chemical knowledge suppose we want to analyse iron by simple titration. So the titration of iron, we all know from our school days, but we do not know how to do that particular titration.

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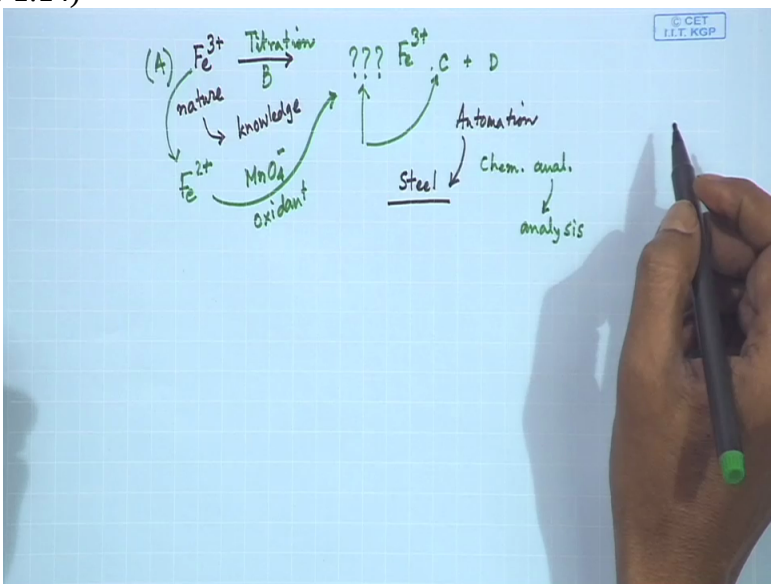

So this particular titration if we consider, so we will just focus our attention on that that we have to analyse iron and iron 3 + is present and this iron 3 + we have analyse, that means whether it is present or not and how much of this iron 3 + is present in that particular sample. So we must have some good knowledge about the nature of this Fe 3 +. So what nature we will be utilising. So that nature gives us some useful chemical knowledge.

So this knowledge basically we have to apply and this knowledge in one way, that if we go for a simple titrametric analysis we all know that Uhh we go for titration, simple bullet pipette titration. So this titration is nothing but if this species is A, we will be utilising some B, so this this is A so we will be utilising this A with B and something is happening over there and our eyes or some instrument such as your spectrophotometer or any other instrument can see the change.

And if there is a stoichiometric reaction, that is A is reacting with B, and we all know that we can produce C and also we can produce some D. And if we can monitor the formation of C in the system, what we find that the production of C will be directly related to the presence of A, that how much A, that means iron is present in the unknown analyte or the unknown sample that will directly be converted to the corresponding C.

So if your titration is done for something where we do not use directly with this Fe 3 + but Fe 3 + we all know that it can be reduced to Fe 2 + and this Fe 2 + can be titrated now with say KMNO4 solution. We all know that the oxidant. So use of that oxidant, that means quantitatively,

as we are able to oxidise this Fe 3 + to the formation of Fe 3 + and towards the end of this titration, all Fe 2 + will be exhausted and will end up with Fe 3 + in the solution.

And this end point will be dictated by some indicator. So this is basically the knowledge what we are talking about. The application of any knowledge or existing knowledge or any updated chemical knowledge can be useful to apply your analytical chemistry to a particular problem. And in this particular case, however problem is that you have to determine the unknown iron concentration in any sample.

So there must be some tension what we are talking in our previous class also that what is analytical chemistry and what is chemical analysis? So what we are talking about just now? That the routine analysis that a particular chemist which is analising the corresponding steel sample which is being produced in a company, so steel production is going on and a continuous monitoring system is there, nowadays, the chemists are not required because if we go for a typical automation, so whatever steel you are producing, the machine can take care.

So automatically, the machine can analyse this particular sample. So that basically can be termed as chemical analysis. So this is not analytical chemistry but this is analysis but when we talk about something that you have to devise from new knowledge, you have to devise from new process, so all these things will come under the purview of analytical chemistry.

So there must be a good distinction or good difference between analytical chemistry and chemical analysis because all we know that okay okay we are going for some analysis but that is not analytical chemistry what will be talking in this particular class. So when we utilise or we go for identification, this particular ore sample what we are talking just now that how this ore can be utilised for that analytical chemistry.

So metallurgists or a metallurgical engineer will be interested to know the quality of the poor. Suppose a haematite or magnetite ore is being used for the production of a very good quality of steel sample. Sometimes, the steel sample can be of a high and steel sample. So how a person which is a metallurgical engineer can evaluate the corresponding economic viability, whether he

or she can use that particular material, that means that particular ore for the reduction of iron sample initially and after that, the iron sample can be utilised for the steel production.

So the effective cost which is being utilised for the steel production which can be compared and it should be meaningless if he find that the corresponding process, that means the trouble what we are taking for analysing the sample gives rise to some bad quality of iron, so the ore is of not good quality. So its value for its contents identification is also important. So that will tell us the corresponding economic viability of that particular ore sample, whether we use that ore sample, whether we buy that ore sample for iron production as well as steel production.

Next is that to estimate its value, that means how we will buy that particular ore, that industry people will be interested to buy that particular ore from another industry from the mining industry, so the mining industry, so the mining engineer is also come into the picture. So the mining engineer will also be interested to know the value, that means the percentage composition of that particular ore. To estimate the value of analysing the sample of the ore.

So starting from the ore analysis to the finished product which is our steel sample is always important. And if we day by day if we go for a complex material because your stainless steel is a very simple steel but if you go for some other high end steel, then some other constituent is being added. Sometimes, we add tungsten, sometimes we add molybdenum. So the analysis of iron, analysis of carbon or analysis of nickel or analysis of chromium as I told you, is a process thing and has been standardised and people are routinely doing for that particular analysis.

But if we try to make some new steel which contains tungsten or which contains molybdenum, we have to go for a a different methodology or a different technique or different instruments for this analysis. So there comes into the picture, the analytical chemist. So it is a real challenge, how to develop and validate that particular method. So if we have a new method and you have to introduce this new method for analysing a particular sample.

So if we have to develop a particular method and you validate that method, it is a responsibility or the analytical chemists' responsibility to develop this particular method and use that particular method to analyse a particular sample. And we basically, the analytical chemist if you are, the analytical chemist can give birth of this particular technique, the methodology, the process and

once it is developed, it can be transferred to some other person who can do the job of routine analysis, day to day analysis or hour by hour analysis.

So he can be a chemical analyst. Both these 2 things are directly related and occasionally we will be utilising these 2 terms that whether we are utilising or whether we are using a chemical analysis. Some methods what we will be using for the chemical analysis and what analytical chemistry perspective how important that particular methodology to be developed, so when a unknown problem comes to us, how to identify?

Suppose if we want to identify some contaminated water sample which has arsenic in it, so the person who is dealing with that particular pollution of that water sample will be interested to know the amount of arsenic present in it. But how it is discovered? The Discover is also very interesting that it has some consequences, the consequences on the plant kingdom, consequences to the animal kingdom or the consequences to the human being.

Because the human being is driving that particular water sample and consuming that water sample, or it can have some skin disease or dermatitis related to that arsenic. But the problem to analytical chemist is that how to determine the amount of arsenic present in what sample which you are considering as a portable water sample or a drinking water sample to you. So that is a real challenge to analytical chemist, how to introduce the corresponding technique or the method of analysis of arsenic depending upon the corresponding concentration, whether this concentration is in the milligram level or it is in the microgram level or it is in the ppm or ppb level.

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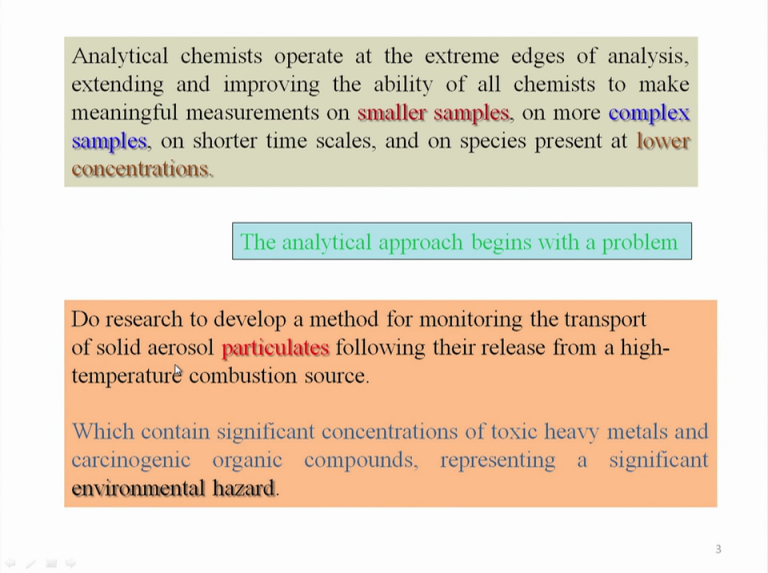

So what we find that an analytical chemist operate at the extreme edges of analysis because if it is a challenge to identify arsenic or the amount of iron in a steel sample some amount of say metal iron, say some medicine or some some supplements, say vitamin supplement, we all know that vitamin B12 contains cobalt. We all know that the day to day daily life we go to the market, to any medicine shop, we buy some sample which is well-known to us, which is becosules which is nothing but B complex capsules.

So these B complex capsules are very useful to us and doctors often prescribe these B complex. So becosules are available to us and how to analyse this becosules capsule because some amount of those vitamin B12 which is the corresponding covilamin is given to the person which has been diagnosed by some deficiency of this vitamin B12 because it causes pernicious anaemia to the person. So this particular analysis will be dependent on the analysis of the corresponding cobalt as well as the whole vitamin B12.

So we can have 2 things, one is the analysis of cobalt. So it can be considered as the analysis of iron. That means the metal iron analysis or it can be considered as the corresponding whole analysis of vitamin B12. So extending or improving visibility that how we can go for meaningful measurements of smaller samples because your medicine or your still very small amount of some other sample what we can use, that some analysis of gem or some gemstone.

So Ruby, we all know that is a typical gemstone of aluminium oxide AL2O3, so within that Ruby, we have some doped amount of chromium. So the amount level of chromium present in this Ruby is very less. So how we can analyse? This is a very small sample. That means, the concentration of that unknown chromium present in Ruby is very less at your arsenic, like your cobalt in vitamin B12 or in more complex samples because what we consider as a complex sample because it is not easy to get that particular chromium from the Ruby sample in solution.

Suppose a chemical analyst only knows how to handle or how to analyse the corresponding chromium, unknown chromium sample in any solution, in a test tube or any beaker or any (()) (14:46) of the spectrophotometer. So that basically gives us some idea that how a sample can be complex. That means, the nature. So nature of the sample is very important. So how we can go for this analysis? So whether it is in the solid-state like our gemstone which contains say chromium 3 + in a matrix of aluminia Al2O3 in Ruby.

So to how to get this chromium 3 + in a solution? So we know how to analyse chromium 3 + in a solution in a test tube. So if this chromium is present, it is very easy to get it. So we can analyse it very nicely if it is present in this particular solution. But how to get this chromium into solution from this gemstone? So is is a very tedious and a difficult process which can be considered and which we discuss in our future classes regarding the corresponding sample preparation.

So sample preparation is a very useful term that how we get or how we carry or how we bring this particular chromium 3 + from the gemstone to the solution in a test tube. So this particular analysis if we go for this analysis of complex samples like your gemstone which is in a solid matrix within a very short timescale because if the person utilising some analytical chemistry laboratory is analysing this by titration, it is definitely a time-consuming process but if we want to analyse 50 or 100 samples in a day, we cannot go for this particular technique or we cannot let that only one chemist or one particular person to analyse this thing.

We must have some boxes where we can fasten the particular technique or the particular analytical technique can shorten the timescale of analysis and what we are discussing also, the lower concentration, very low concentration, parts per million or the parts per billion concentrations, how we can handle for these unknown samples. So we can have a typical

analytical approach that I am trying to tell you all that this approach is very important that how we can go for a typical analytical approach.

We must have a very good analytical mind for that and we must have a typical focus for that that we try to identify this particular unknown thing. So it is basically a discovery, it is basically an identification, it is basically a research related to something which is discovered. So if we try to understand that something unknown species is present but the nature of the unknown species is not known to us, suppose if it is a typical metal ion but we do not know the nature of this metal ion about metal ion is present, whether it is iron, whether it is cobalt or whether it is chromium.

We must have to go this particular problem is, that problem will be the overhand and how to tackle this particular problem. So we have to do some amount of research component, research is nothing a very big thing. That we have to have some standardised procedure so we can go for researching this things are fruit to the 1st will of a method for monitoring say the transport of aerosol particulates.

So when we see that automobile exhaust we were talking about in our previous class, that automobile exhaust is giving different types of gases and we want to analyse those gases for a particular understanding that how the automobile or the exhaust, suppose some generator is also running and generator is also giving some exhaust, our air conditioner is also running, our refrigerators are also running. So all these machines are giving some gases to the environment.

So apart from these gases, if we get something which is solid aerosol that the solid particulates we all know that which is present in environment which is not settling down on the surface, but which is in the suspension. So these particulates, when it is released at a high temperature combustion source, suppose the combustion engine, we call at that IC engines, the internal combustion engines what we use for our 2 wheelers, what we use for our 4 wheelers or motorbikes or aeroplanes and all these.

So is that, at a very high temperatures we are burning the fuel, so at very high temperature, the particulates, forget about anything, we can have the carbon particles in it because all our fuels based on carbon. So the petroleum, the diesel, the biological thing what we are getting because

everything is coming from our trees, the natural products. So this high-temperature combustion can release huge amount of those carbon particles into the nature into the environment.

So we have to go for this particular particulate that how much particulates we can have in our hand. So some filtering process, we can have. Suppose we use some filter. So filter can trap to solid particles added it allows only the gaseous matter into the environment or some monitoring system, we take those solid particulates from the filter so the from the filter, we take out those solid particulate matters and we analyse those for their identity.

So definitely, against the analytical chemistry will come into the picture to identify the nature of those solid material. So if they contain also some other material, that not carbon, if they contain some significant concentrations of toxic heavy metals because we all know that long back, our diesel, our petrol has given something which you call as to increase their octane number, we add Tetra ethyl lead.

So, Tetra ethyl lead if we just simply know the name, so try to understand by knowing the name, it is the Tetra ethyl so definitely, it will the ethyl group containing some lead. So when that particular fuel when we burn in our engine, the diesel engine or petrol engine, so the lead what is present in that particular thing cannot be completely burnt completely to something else. So lead can come out as some solid lead particles only.

Similarly, cadmium if it is present in the particular fuel, because the quality of fuel is also important when we buy that particular most successful what we burn in our kitchen, in our home, the liquid petroleum gas, which is also coming out from the petrol. So from the petroleum industry, we get that LPG but it is gaseous fuel, we can have, we can burn everything.

So whatever is present over there, we can burn it to the gaseous product but the problem with it is that the aerosol solid particles, the solid particulate matter which is there, so heavy toxic metal ions, it can be led, it can be particularly, it can be some other metal salt. So very fine particles if it is in the air, what is happening? We can inhale, we can inhale that particular solid material, solid particles we can inhale and it can go to our body.

It can go to our lung also. So basically, if our air is not pure, if it is contaminated with all this heavy metal ion and some other organic compound be considered as carcinogenic which is

cancelled producing, cancer causing. So some organic matter is present like say single cigarette smoke we all know, a single cigarette smoke can give rise to carbon monoxide which is also very toxic.

Even if somebody consuming cigarette smoke and that cigarette smoke is coming to the environment, and when the person is exhaling, the person is releasing that particular smoke free environment, the person who is taking that particular smoke, is taking that higher concentration but the person who is in the surroundings who is taking or is compelled to take, compelled to inhale the gases which is coming out from the smoker so that percentage is also very high. It is about 20 ppm of carbon monoxide.

So that 20 ppm of carbon monoxide will be contaminating the corresponding environment. So that environment is there and that environment can take care of that particular comment monoxide and ultimately that carbon monoxide will be consumed by the person who are living in that particular environment. So not only the carcinogenic carbonic compound, all those gases like the nitrogen oxide, the carbon oxides, all are will also can be carcinogenic. And they basically represent a significant environmental hazard.

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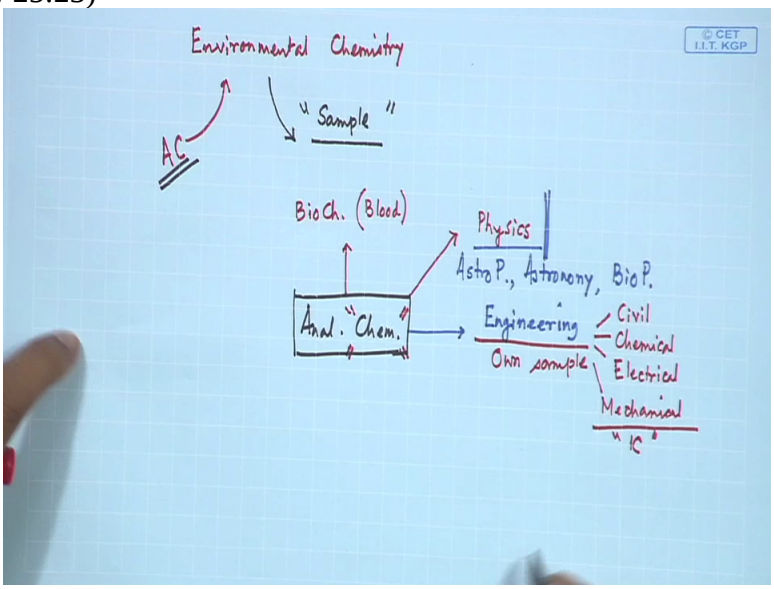

So the analytical chemist can also can talk in terms of the corresponding environment and we can consider it as the corresponding environmental chemistry. So analytical chemist can have some

good role. So as a subject as I told you, we can consider AC as an analytical chemistry, similarly we can consider AC as the corresponding analytical chemist. So that analytical chemist can have a useful role to play in the environmental chemistry.

Only difference with that with that of our metallurgical engineer or a corresponding uhh uhh that mining engineer is that we are not talking in terms of the environment. So how we get the sample. So to an analytical chemist, it is very easy to understand that our sample is only different. From our very first-class, what we are talking about the corresponding sample what we are getting, this particular sample from a steel, from a ore, from our blood sample, now we are getting this particular from the environment, only the sample.

So how to get that particular sample? So our analytical chemistry is therefore a typical central measurement science as I told in the very beginning of our class, it can be utilised for so many areas basically. So starting from our knowledge of chemistry, so knowledge of chemistry not only the typical branches of organic chemistry, inorganic chemistry or physical chemistry, but we can have also the importance of the biological chemistry.

So biological chemistry as we are talking about medicine and blood, so analysing all these things, so all these samples which are physical samples what we talk about whether it is the biochemical sample, whether it is inorganic sample, or whether it is organic sample and what we can consider as a physical sample? Physical sample is that a solid material or a liquid material whether we will be able to identify physically.

What a physicist can do. So if we are able to understand physically that particular sample so that is equal chemistry can also be benefited by that. Similarly the physics, the subject physics is also dependent on analytical chemistry because if your samples we get, that means the solid-state what we are getting, suppose somebody is making some solar cell, somebody is making some uhh corresponding super conducting material, so basically because this physics is directly related to the material science, so the physics what is being utilised to understand this analytical chemistry is nothing also related to our astrophysics.

Because some samples can come from the other part of this particular universe so the astrological thing that means the astronomical thing or astronomical physics can have some

understanding. So then astronomy and biophysics, so the bar physical sample can also be utilised for this particular analysis. And obviously the subject engineering, so the subject engineering can also be benefited by a typical knowledge of analytical chemistry.

So what I am trying to say to you is that is not atypical chemistry, is not a typical chemical knowledge but is a typical understanding or a typical idea how we can apply because chemistry will play definitely a central role to understand that thing but that is a very basic or a very trivial knowledge but how to utilise this to analyse the sample because the engineer, the particular engineer as I told you that a mining engineer or a metallurgical engineer knows his sample very easily because the engineer will have typical understanding that how he or she can make his own sample.

So they can have their own sample for analysis. So if you have your own sample in your hand, then you can think of what particular this basic understanding or basic knowledge of analytical chemistry can be utilised to explain the different problems because all these problems, all these engineering problems will be in your hand. So a civil engineer can also be benefited.

Definitely, a chemical engineer is also there, then electrical engineer and then also the mechanical engineer. Thus we see that how the engineering, the subject engineering because the environmental engineering is also a subject, how the subject engineering can also be benefited if we have a very basic knowledge of analytical chemistry because this is not a very special knowledge, is a very simple knowledge. It can be given to the school kids also.

So this analytical chemistry knowledge, how we can utilise, so next time what we will be utilising or what we will be discussing that what are the civil engineering samples we can, we know because as a chemist, as an analytical chemist also we know what sample civil engineers wants to know is a cement sample.

Similarly, how a chemical engineer wants to know particular the corresponding material, similarly the electrical engineer can also handle some materials and all these things and also some mechanical engineers that what we are talking about the automobile exhaust because automobile subject, the corresponding IC chip, so they are also burning the petrol, they are also contributing the gases into the air, so how a mechanical engineer can modify the corresponding

IC engine such that your exhaust the amount of exhaust what is being given to the environment can be minimised.

So every time a mechanical engineer is devising a engine, a combustion engine, say internal combustion engine, he should have some important idea by monitoring the exhaust gas what is coming out from his engine. So next we will continue. So we just have some other areas. So all these different areas how they can be benefited by the simple knowledge of analytical chemistry. Thank you very much.