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What is the Atomic Absorption Spectrophotometer (AAS)?

A Tradition of Innovation

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The AAS is fundamentally a light source and a light measuring device. It can measure light very accurately.

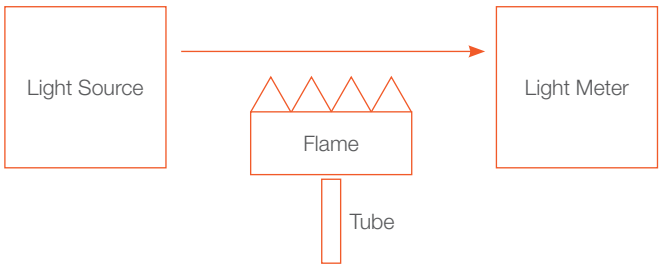
How does it work i.e. how does it measure concentration of metals?

The AAS works by measuring the amount of light that is removed between the source of the light and the measuring device. The light is removed, or lowered in intensity, by atoms of various metals. The atoms remove, or absorb, the light by getting energised by the light. The energy that it takes to change the energy state of the atoms is effectively provided by the light – the more energy that is absorbed, the more light is removed.

How do the atoms of the metals get in the way of the light?

The light passes through an area in between the source and the detection unit that has a flame. Solution is sucked up through a very fine tube and into the flame after hitting a glass bead to break it into fine droplets. The fine droplets become a fine mist in the flame and the solution vaporises. The atoms can then absorb the light passing through the flame.

Diagrammatically, the AAS looks like:



How does the AAS know what element it is looking at?

The energy levels are unique, not only for each element, but even for various energies for the same element. These unique energies are related to the wavelength, and each wavelength will be unique for each element. The "best" wavelengths for each element are marked on the lamps that produce the light; however, other wavelengths are also produced.. The lamps are made so that they produce the light that is peculiar to that element. For that reason, separate lamps are used for each element.

What can cause a wrong reading?

There are two areas that can cause wrong readings. One is the rate the solution enters the flame, and all the things associated with that, such as the tube blocking, the burner blocking, even the viscosity of the solution being sucked up. To make this even more of a problem, the rate the solution is sucked up is adjustable. If that adjustment gets changed – either deliberately or by accident – the rate will change. Changing the rate of the uptake can then also change the way the solution gets broken into droplets, so there can be very complex interactions happening.

The second way wrong readings can be produced is in the way the light is affected by various factors. If the light is reduced in some way that isn't the actual atoms – for example simply by dirt blocking out the light – it will register as some of the element being present. There are even some things which are normal physics which will affect the way the light is reduced. The whole principal of AAS reading depends on having a straight line graph (of the light absorbed plotted against the amount of element in the solution), or at least a curve that is consistent and stable so it is predictable. The AAS machine has a computer that will create the best curve for the absorbances.

It is the fundamental function of the AAS reader to ensure that the readings remain consistent, i.e. the curve stays the same during the time the unknown solutions are being read.

There are two main ways the curve will change:

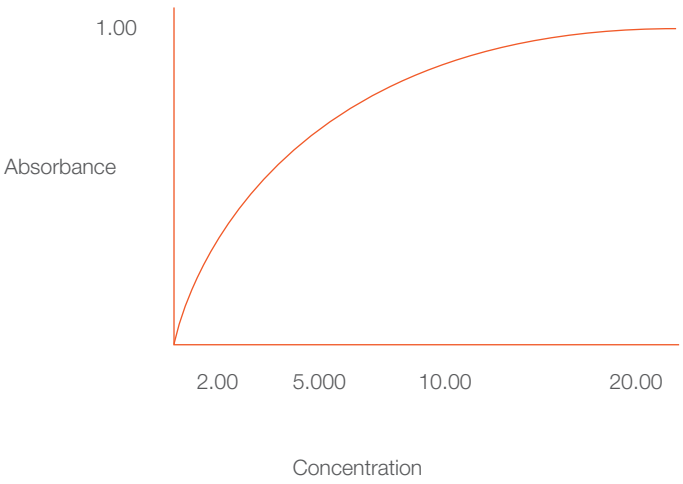
1. The characteristics – or the shape - of the graph will change. If that happens, the curve will need to be reset by measuring all of the standards again and getting a new line to measure the unknown solutions against. This is called recalibration.
2. The shape of the graph stays the same, but the intensity of the reading (i.e. the amount of absorption) drops. When this happens the graph simply looks smaller, and it can be reset simply by measuring one sample and telling the machine to reset the graph in the same shape but with the new size. This is called rescaling.

Setting up the AAS to read.

When setting up the AAS it is important to know that even the best conditions will not produce a straight line when the absorption of the element is plotted against the amount of element in the sample for most elements. This is caused by normal physics of absorption. The factors causing the most effect are

1. Doppler effect. This simply means the wavelength will change as the atoms go toward or way from the detector. Because the amount of the element is measured by the amount of the light of that specific wavelength, the less amount of light of that wavelength being absorbed means that the machine sees the actual amount present as being less.
2. Collision Broadening. This (also simply) means that the wavelength will change whenever a collision occurs between the atoms. As with Doppler Broadening, the change in wavelength is seen as a lowering of the intensity of the amount of element. The effect becomes more pronounced with higher concentrations. Most of the effects are caused by high concentrations, and hence there is a limit to what can be measured.

These effects can be seen on a typical graph of concentration vs absorption:



It can be seen that we can determine the concentration by measuring the absorbance at the lower levels, but any slight change in absorbance can make a big difference in concentration at the higher levels.