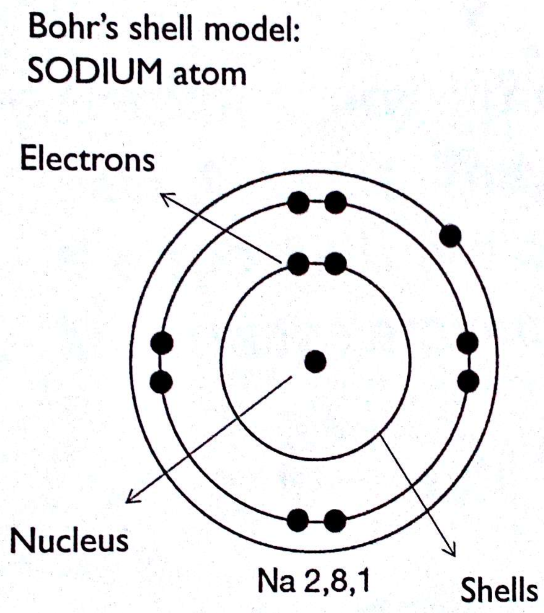

ATOMIC
ABSORPTION
SPECTROSCOPY
By: Mae

ATOMS



- Nucleus- protons (+ve) and neutrons (neutral).
- Electrons- (-ve) charged particle.
- Shells- consists of subshells.

Shell, Subshells, Electrons

- Electrons are arranged according to their energy levels. They are arrange in subshells, the subshells are arrange in shells and shells are arrange around the nucleus.

Atom
(around the nucleus)

Shells

Subshells

Electrons

!Note:
Electrons that are near the nucleus has a lower energy level than the electrons that are much far away. However, they experience stronger attraction in the nucleus than those ones that are further away.

‘Exciting’ atoms

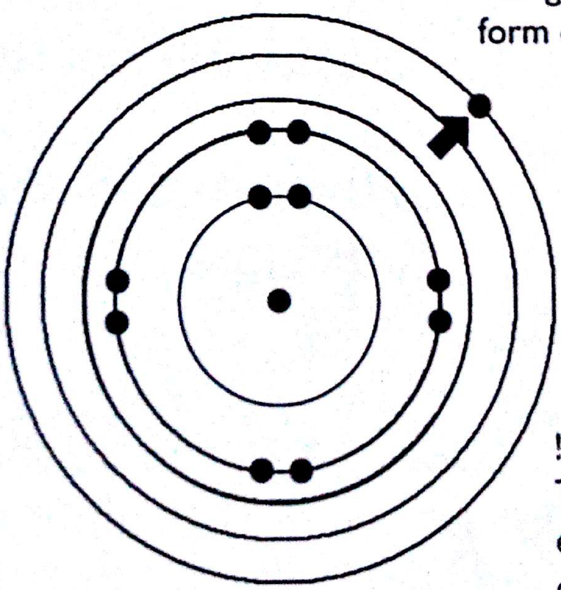
- ‘ground’ state: is a status where the atom’s electrons are in their lowest possible energy level. (stable)

- ‘excited’ state: another status where the atom’s electrons absorb enough energy to be promoted to a higher level. Therefore, they are not in their lowest energy level. (unstable)

'Excited' atom

Generally, atoms are in their 'ground state' but when an atom receives enough input of energy that their electrons requires to be promoted to a higher energy level. They will then turn to their 'excited state'.

Since, an atom's excited state is very **unstable** it rapidly 'jump' back down to its ground state. This 'jump' then causes the atom to release the energy it absorbed in the form of *photons of light*.



Excited state: sodium atom

!Note:
Take note that the electron can go back down to its 'original' place in more than one jump.

What is AAS?

(AAS) Atomic Absorption Spectroscopy is:

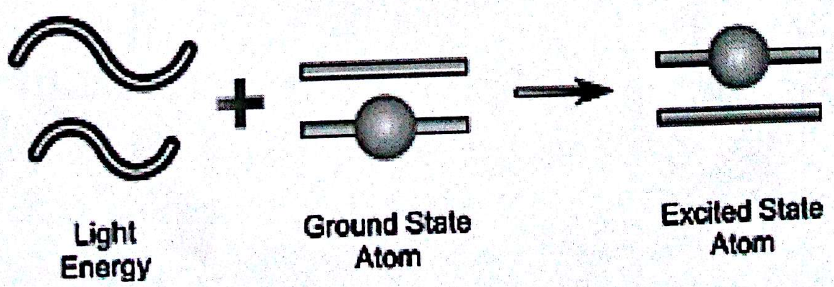
- Quantitative technique

- Typical samples: low viscosity samples

- Generally uses to determine the amount of several metals (e.g. Cu, Fe, Zn, Mg) in the soil, blood, air, water, and food.

- Occasionally can be use as a qualitative technique (can indentify chemicals that are present) – 68 elements

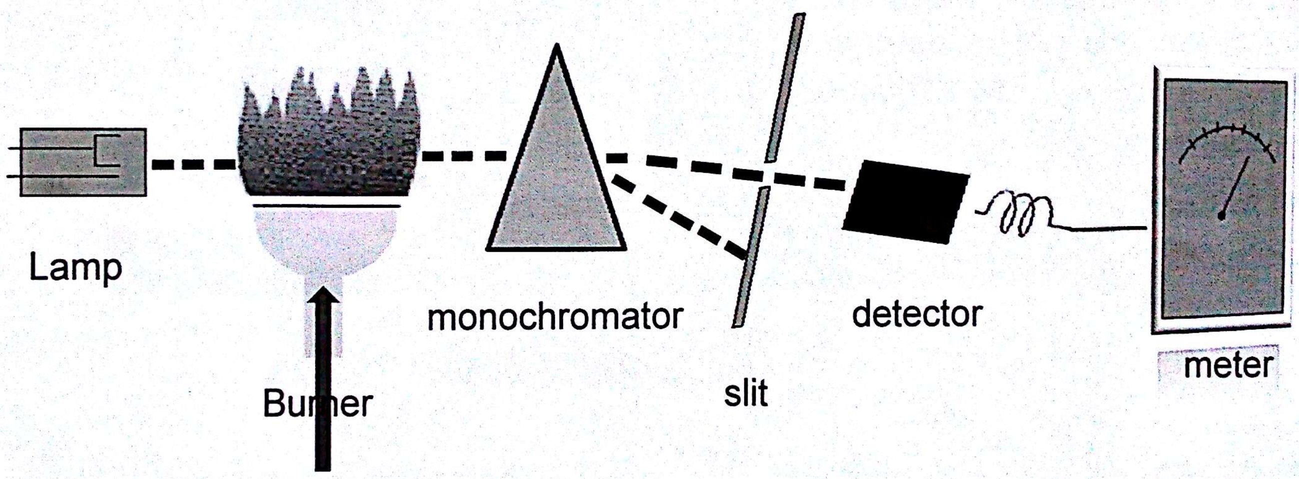
- In the electromagnetic spectrum, it uses the visible part to detect the presence of metals (p.77 chem book)
- Foundation of the technique: the absorption of the light energy that has the right wavelength causes the electrons from the sample to be promoted from a lower energy level to a higher energy level.



Discovery of AAS

- 1952, the Australian scientist Alan Walsh was working on the measurement of small concentrations of metals at the CSIRO using atomic emission spectroscopy.
- The idea of AAS came into his mind as he was gardening at his Melbourne home. On the normal Sunday morning he had the idea about looking at the light *absorbed* by the atoms except than looking at the light they *emits*.
- Alan Walsh did not just discover a process that has the ability to save lives but also proven that atoms will only absorb light that has the EXACT value requires to promote their electron to a higher level.

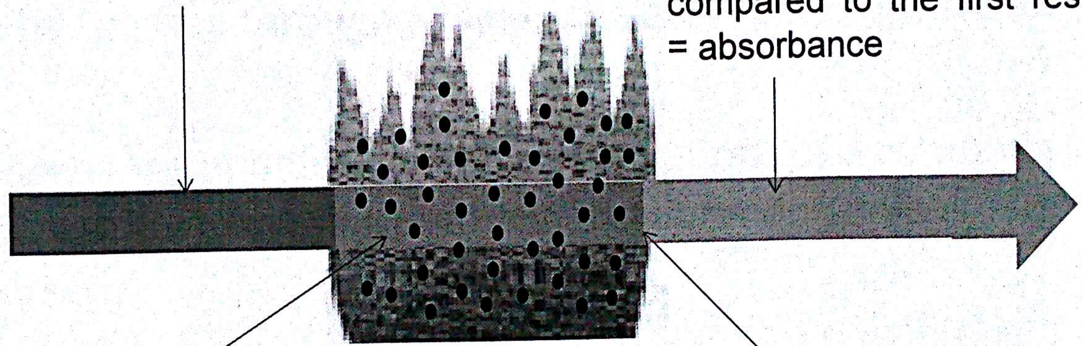
How does AAS works?



How can we obtain the data?

The intensity of the light coming through the cathode lamp is measured

The intensity of the light is then again measured and compared to the first result. = absorbance



The higher the concentration of the metal that is being observe in the sample the greater the absorbance.

The light can then be absorbed by the atoms from the sample that has been vaporized in the flame.
This wavelength can then promote the electrons to a higher energy level = excited state

How do we analyze the data?

- By comparing the light intensity that has passed through the sample (refer to previous diagram) with that of the same light after it has passed through a blank, the absorbance is measured.

- The absorbance of different standard solutions of a compound of the element are also measured and a calibration curve is constructed.

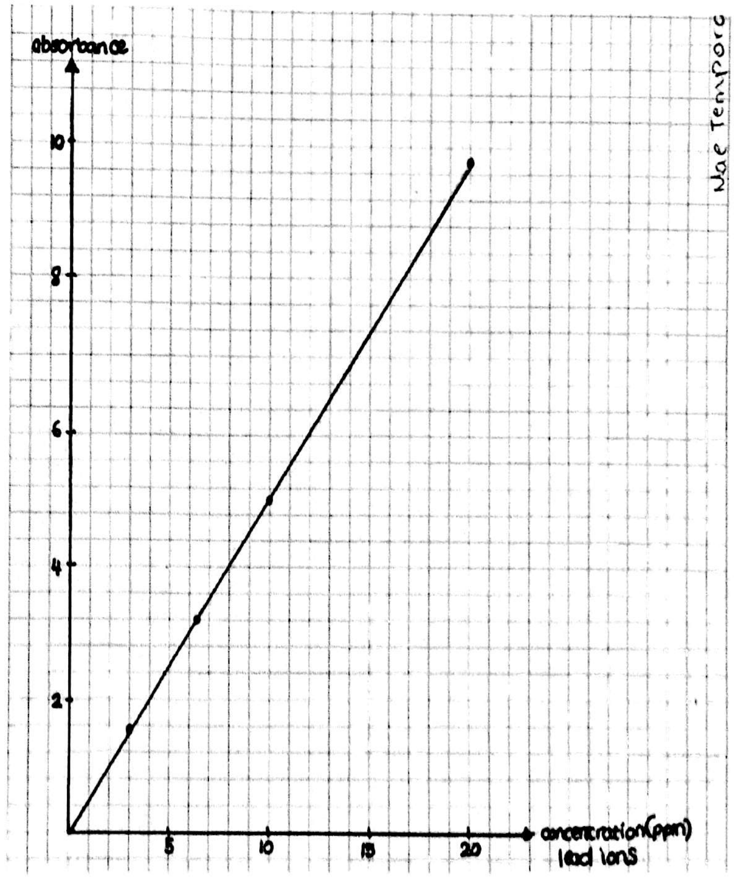
- Absorbance is plotted against concentration. We then use the calibration curve to determine the unknown concentration.

Example of a Calibration curve

- An AAS was used to determine the concentration of lead ions (in ppm) in fish. The AAS was set up with a lamp that emitted light with a wavelength that is absorbed by lead atoms. The AAS was calibrated using different solutions containing known concentrations of lead ions. The graph on the next slide shows the variation of absorbance with the concentration of lead.

  A 2.0g sample of the fish was ground up and heated on a hot plate with 10 ml of nitric acid. This mixture was filtered and then sprayed into the flame of the AAS. The absorbance reading was 6.0. Determine the concentration of lead ions in the fish.

Graph:


absorbance
10
8
6
4
2
5
10
15
20
concentration(ppm)
lead ions
Mae Tempora

Solution:

10 mL $\downarrow$ 2g fish

⑥ - abs $\downarrow$ 12 ppm = 12 $\mu g/mL$

$C = \frac{m}{V}$

$m = 12\ \mu g/mL$

$m = 12\ \mu g/10 =$

$C = \frac{m}{V} = \frac{12/10}{10} = 12\ ppm \times 2 = 6$ abs

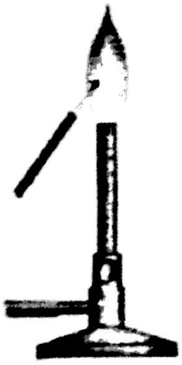
concentration of Lead in fish + nitric acid

$10 \downarrow$ 10mL = 2g fish

$C = 12\ ppm \times \boxed{\frac{10\ mL}{2g}} = \frac{120}{2} = 60$ ppm

concentration of Lead in fish

AAS, Flame test, UV-Vis, ICP-AES



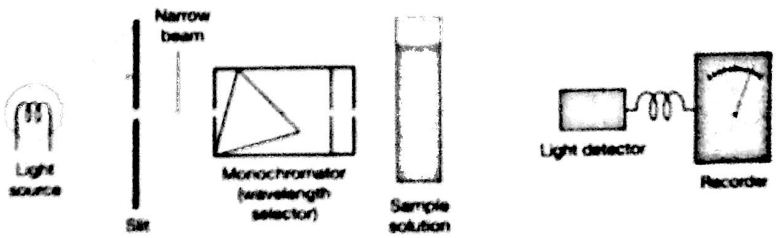
Flame test: uses the basic principle of AAS. The flame test is basically done by exposing a sample that is in observation into a non-luminous Bunsen burner flame.

UV-Vis spectroscopy: is also similar to AAS in number of ways:

- Have the similar basic principle which is promoting electrons from lower energy level to a higher energy level.
- Both techniques uses similar steps to interpret results.

Dissimilarity:

- AAS – uses 'visible' part of the emission spectrum
- UV-Vis – 'ultraviolet' part of the emission spectrum



ICP-AES

- Inductively coupled plasma (ICP) can produce very high temperatures (7 000 – 10 000 K) to create the plasma instead of a flame.

- All the atoms in the sample are excited and able to emit electromagnetic radiation as they return to their unexcited ground state.

Some of its advantages over AAS:

- can be used to identify most elements
- Can identify many elements at once-50 elements simultaneously (AAS can only determine one at a time)
- Is very fast (analysing 70 elements takes 2 minutes).

ICP-AES

- Inductively coupled plasma (ICP) can produce very high temperatures (7 000 – 10 000 K) to create the plasma instead of a flame.

- All the atoms in the sample are excited and able to emit electromagnetic radiation as they return to their unexcited ground state.

Some of its advantages over AAS:

- can be used to identify most elements
- Can identify many elements at once-50 elements simultaneously (AAS can only determine one at a time)
- Is very fast (analysing 70 elements takes 2 minutes).

Common application of AAS

- Mostly used in: mines, food industries, environmental control, petroleum products as they:

- detect deficiencies / excessive amounts of certain metals in our body fluids such as: our blood and urine

- Tracks harmful metals in our food/drinks

- analyze metal ions that are polluting the soil, air and water.

- Investigating different locations to test for different elements present and how much of these elements are present.

- Analyze metals present in engine oils.

ADVANTAGES & DISADVANTAGES:

- Precise and very sensitive
- accurate results can be obtained.

- Moderately expensive
- Can only process one element at a time.
- Slower than ICP-AES
- Can only identify limited types of elements

A life-saving technique

- Canada: AAS was used to determine unsafe levels of lead in children who was lives nearby a lead smelter.
- Japan: From 1932 to 1968, AAS was used to identify the reason why over 3,000 residents who lives near the Minimata Bay started showing neurogical problems and pregnant women starts giving birth to impaired children. Scientist starts taking samples and performing AAS process; AAS results shows a very high concentration of mercury in their blood. This result on stopping the company, Chisso corporation who dumped approximately 27 tones of mercury in the bay.

Safety Precautions

→ Exhaust System: AAS flames produce large amounts of heat & the resultant fumes & vapours may be toxic.

→ Gas Cylinders: should be located outside of the laboratory in a cool well-ventilated area.

→ Flammable Solvents: The combination of flame & solvent is a hazardous situation. Always use a solvent with the highest flashpoint consistent with the analysis being conducted. Use covered containers & the smallest practical volume.

→ Burners: Keep burners clear & do not allow them to block.

→ UV Radiation: Hazardous UV radiation is emitted by flames, hollow cathode lamps, analytical furnaces. Never look directly at any of these. Operate the AAS with the door or flame shield closed and wear appropriate safety glasses.