

IDENTIFICATION OF UNKNOWN
ELEMENTS BY EMISSION SPECTRA

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Identification of Unknown Elements by Emission Spectra.

Purpose:

The purpose of this lab is twofold. First we would like to show with some known samples that it is possible to identify samples by their emission spectra. Once we establish the reliability of the system we would like to identify some odd colored "moon rocks" picked up by Dr. John Amend (legally) at "Craters of the Moon" Park in Idaho.

History:

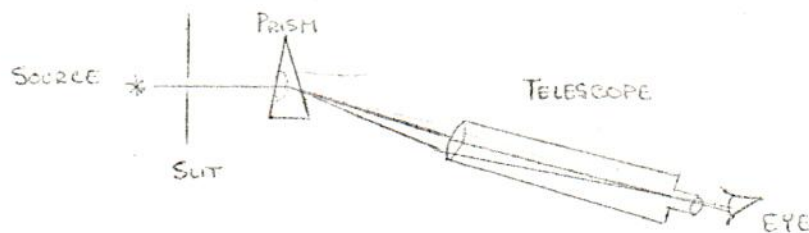
Issac Newton probably made one of the very first spectroscopes in 1663 while studying optics. His spectroscope consisted of a small hole in a shade (the slit), a prism (the refracting medium) and pieces of light colored paper for a screen. While, crude, this tool did spread white light into its various colors.

Josef Fraunhofer in 1814 made what one might call the first modern spectroscope. The only addition he made to Newton's spectroscope was a Theodolite telescope (a surveyor's telescope) to view the light coming through the instrument. This improved the scope so much that Fraunhofer could actually count the absorption lines in the apparently white sunlight (these were not correctly

interpreted until 35 years later). It is with this same type of instrument that Bunsen and Kirchhoff discovered Cs and Rb in 1861.

Today Spectroscope construction varies with the experimenter and the experiment but basically it has the same construction as Newton's first:

- 1) A source.
- 2) A slit to make the source a point source.
- 3) A prism or grating to separate the colors or frequencies.
- 4) A telescope to amplify the separation.
- 5) A read out device (film, screen, the eye, or a phototube).



Theory:

It is known that electrons do not exist in a continuum of energy states about the atomic nucleus but rather exist in certain discrete energy levels. When an electron changes states it must either absorb or emit a quantum of energy designated by the change in energy levels.

This was first proposed by Max Planck in 1900. Planck's

equation says that a change in energy ΔE is equal to a constant (h) times frequency (ν) of the energetic photon emitted.

$$\Delta E = h\nu$$

where $c = \lambda\nu$

$$\nu = \frac{c}{\lambda}$$

or $E = \frac{hc}{\lambda}$

c = speed of light.

λ = wavelength of light.

ν = frequency of light.

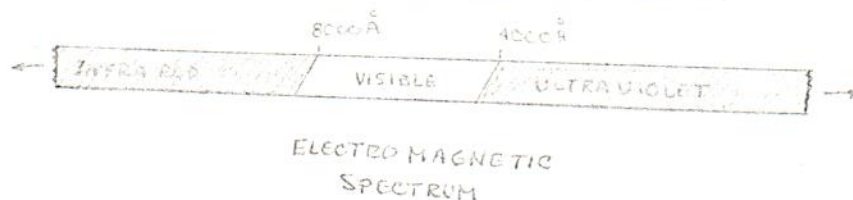
What we will be measuring then is the wavelength of the light (and indirectly-energy of light) given up by excited electrons in a sample. The sample will be excited by vaporizing it in a carbon arc.

Because each element contains atoms with different number of electrons around it and a different electronic arrangement each element gives off discrete characteristic energies when these electrons are excited. These energies are photons of different colors or wavelength. The conversion can be made between energy and wavelength using Planck's equation.

Because this light given off by the excited atomic electrons is unique for that element one can use this spectra of light to identify the element. This might be called an "atomic fingerprint".

Apparatus:

We used two spectroscopes. One was a Bausch & Lomb (1.5 meter) and the other was a Baird (3 meter). The B&L used in the first part of the experiment gives spectra in the 2000 to 4000 Å range. The Baird was in the the same range, but can be used in the visible and infrared also.



Both instruments vaporized the samples with a high current carbon arc and used a concave mirror with lines cut on the surface as a grating. The spectra of each was recorded on 35 mm film. The diagram below shows the basic arrangement of the equipment.



Procedure:

The first portion of the experiment consists of vaporizing a sample (in a small hole in a carbon rod) in the B&L spectrometer and recording the results on a strip of film. These will eventually be reproduced onto paper and used as a worksheet. There are six known and three unknowns (a mixture of the knowns). The unknowns will be identified by comparing the spectral lines of all known and picking

out the elements that best match the spectral lines of the unknown. The fact that one can use these lines as "fingerprints" to identify unknown elements is the basis of the next experiment.

In the second part of this experiment we are looking for elements that give our "moon rock" samples their unusual colors. The procedure is the same as above except that we used the Baird 3meter spectrometer. The spectra of the unknown samples were compared with a set of spectral lines for most elements in this region of the electromagnetic spectrum. Iron was the reference used to align our film strip with the standard. Once aligned the other elements were picked from the spectrum and recorded on the data sheet.

Comments and Conclusions:

One could make a spectroscope of this type using a carbon arc light source, a "good" ~~refraction~~ diffraction grating and ordinary 35 mm slide film. One could improvise a slit and a film holder with a little practice. The exposure time will vary with the equipment used but our times were 3 seconds for iron and 5seconds for the rest.

The student should be able to identify different elements using the spectral worksheets made in the first of this lab. with this experience he could work out the elements in a completely unknown sample.

The elements listed on the data sheet are those that we are confident are in the sample. There may be more but our standard did not cover the entire periodic chart and we only recorded those that had at least two or more lines that matched.

We are certain that there is no organic material in the sample as we ran an I.R. test on some acetone that was used to leech the sample. The process involved boiling the samples in acetone for about an hour. The only thing we extracted was a small amount of water.

(47)

MOON ROCK SAMPLES AND SOME KNOLWS
EXPOSURE TIME 4 to 5 sec.

(55)

REEL FILM

(6)

Fe

On

1202
Samples

EASTMAN 9 TH

100

54

EMISSION SPECTRA

TIME FOR EXPOSURE $\approx$ 3 TO 5 SEC.CURRENT USED $\approx$ 8 AMPS

WAVELENGTH OF LIGHT EMITTED

SAMPLE (1,2,3) $\approx$ 2000 TO 4000 ÅSAMPLE (4,5,6) $\approx$ 2300 TO 3700 ÅSAMPLE
(4)
(BLUE)

(CuO)

(BRASS)

LAVA
SAMPLE
(5)
(ORANGE)

(IRRADIATE)

LAVA
SAMPLE
(6)

(BIG CHUNK) (SM. GR. CH.)

Al

Al
AsAg
AlAg
Al

B

Bi
Ca
Cd
CoCr
Cu
FeCu
Fe
Ga
Ge
In
IeGe
InK
Li
Mg
Mn
Mo
Pb
Rh
Si
Sn
Sr
Ta
Ti
V
Zn
Na
NiMg
Mn
MoSi
Sn

Ti

Zn

P

Cu
FeCu
FeCu
FeMg
Mn

Mg

Mg

Pb

Sn

Zn

Si

Na

Ag
AlAg
AlCr
Cu
FeCu
FeLi
Mg
Mn
Mo
PbK
Mg
Mn
Mo
Pb

Si

Si

Sr

Ti
V

Na

Na
Ni

LAVA Sample with blue crystals attached