Chemistry Unit 2
Spectrometry
Katie Bennett

Spectrum

Definition: The several coloured and other rays of which light is composed, separated by the refraction of a prism or other means, and observed or studied either as spread out on a screen, by direct vision, by photography, or otherwise.

Introduction to Spectroscopy

Spectroscopy is a complex art - but it can be very useful in helping scientists understand how an object like a black hole, neutron star, or active galaxy is producing light, how fast it is moving, and even what elements it is made of. A spectrum is simply a chart or a graph that shows the intensity of light being emitted over a range of energies. Spectra can be produced for any energy of light - from low-energy radio waves to very high-energy gamma-rays.

Spectra are complex because each spectrum holds a wide variety of information. For instance, there are many different mechanisms by which an object, like a star, can produce light - or using the technical term for light, electromagnetic radiation. Each of these mechanisms has a characteristic spectrum.

The Electromagnetic Spectrum

White light (what we call visible or optical light) can be split up into its constituent colours easily and with a familiar result - the rainbow. All we have to do is use a slit to focus a narrow beam of the light at a prism. This set-up is actually a basic spectrometer.

The resultant rainbow is really a continuous spectrum that shows us the different energies of light (from red to blue) present in visible light. But the electromagnetic spectrum encompasses more than just optical light - it covers all energies of light extending from low-energy radio waves, to microwaves, to infrared, to optical light, to ultraviolet, to very high-energy X- and gamma-rays.

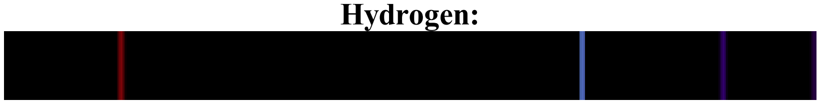
Line Emission

Instead of using our spectrometer on a light bulb, what if we were to use it to look a tube of gas - for example, hydrogen? We would first need to heat the hydrogen to very high temperatures, or give the atoms of hydrogen energy by running an electric current through the tube. This would cause the gas to glow - to emit radiation. If we looked at the spectrum of light given off by the hydrogen gas with our spectroscope, instead of seeing a continuum of colours, we would just see a few bright lines. Below we see the spectrum, the unique fingerprint of hydrogen.

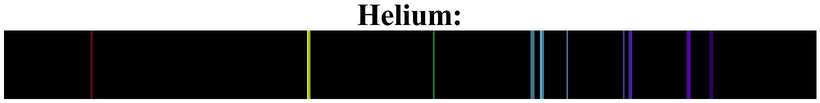
These bright lines are called emission lines. Remember how we heated the hydrogen to give the atoms energy? By doing that, we excited the electrons in the atom - when the electrons fell back to their ground state, they gave of photons of light at hydrogen's characteristic energies. If we altered the amount or abundance of hydrogen gas we have, we could change the intensity of the lines, that is, their brightness, because more photons would be produced. But we couldn't change their colour - no matter how much or how little hydrogen gas was present, the pattern of lines would be the same. Hydrogen's pattern of emission lines is unique to it. The brightness of the emission lines can give us a great deal of information about the abundance of hydrogen present. This is particularly useful in a star, where there are many elements mixed together.

Each element in the periodic table can appear in gaseous form and will each produce a series of bright emission lines unique to that element. The spectrum of hydrogen will not look like the spectrum of helium, or the spectrum of carbon, or of any other element.

Hydrogen:

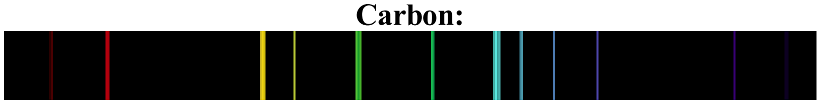


Helium:



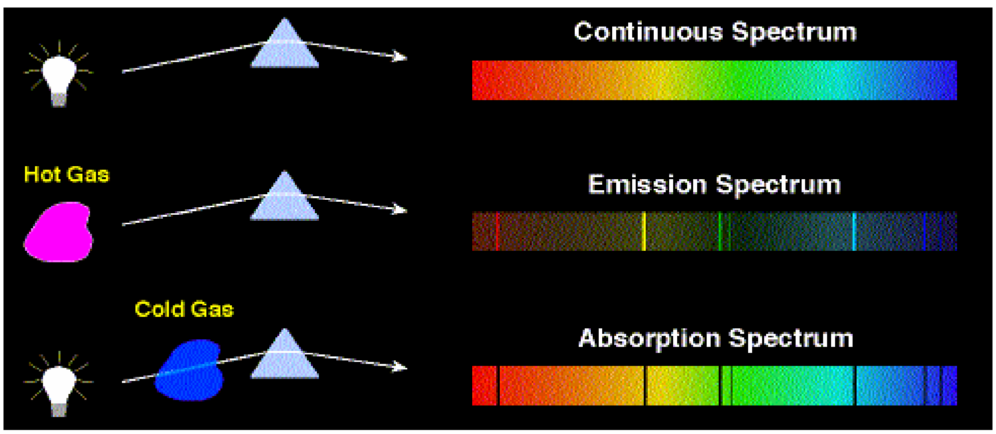
The spectrum of hydrogen is particularly important in astronomy because most of the Universe is made of hydrogen.

Carbon:



We know that the continuum of the electromagnetic spectrum extends from low - energy radio waves, to microwaves, to infrared, to optical light, to ultraviolet, to X and gamma-rays. In the same way, hydrogen's unique spectrum extends over a range, as do the spectra of the other elements. The above spectra are in the optical range of light. Line emission can actually occur at any energy o f light (i.e. visible, UV, etc.) and with any type of atom. However, not all atoms have line emission at all wavelengths. The difference in energy between levels in the atom is not great enough for the emission to be X -rays in atoms of lighter elements, for example.

Differences between Emission spectra and Absorption Spectra



http://csep10.phys.utk.edu/astr162/lect/light/spectra2.gif

Spectra and Astronomy

In a star, there are actually many elements present. The way we can tell which ones are there is by looking at the spectrum of the star. The science of s pectroscopy is quite sophisticated. From spectral lines astronomers can determine not only the element, but the temperature and density of that element in the star. Emission lines can also tell us about the magnetic field of the star. The width of the line can tell us how fast the material is moving, giving us information about stellar wind. If the lines shift back and forth, it means that the star may be orbiting another star - the spectrum will give the information necessary to estimating the mass and size of the star system and the companion star. If the lines grow and fade in strength we can learn about the physical changes in the star.

Spectral information, particularly from energies of light oth er than optical, can tell us about material around stars. This material may have been pulled from a companion star by a black hole or a neutron star, where it will form an orbit ing disk. Around a compact object (black hole, neutron star), the material in this accretion disk is heated to the point that it gives off X-rays, and the material eventually falls onto the black hole or neutron star. It is by looking at the spectrum of X-rays being emitted by that object and its surrounding disk, which we can learn about the nature of these objects.

References

Websites used

http://csep10.phys.utk.edu/astr162/lect/light/absorption.html 15/01/09

http://ardictionary.com/Spectrum/12142 15/01/09

http://imagine.gsfc.nasa.gov/docs/science/how_l2/spectra.html 15/01/09