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Splitting light

Spectroscopy at work

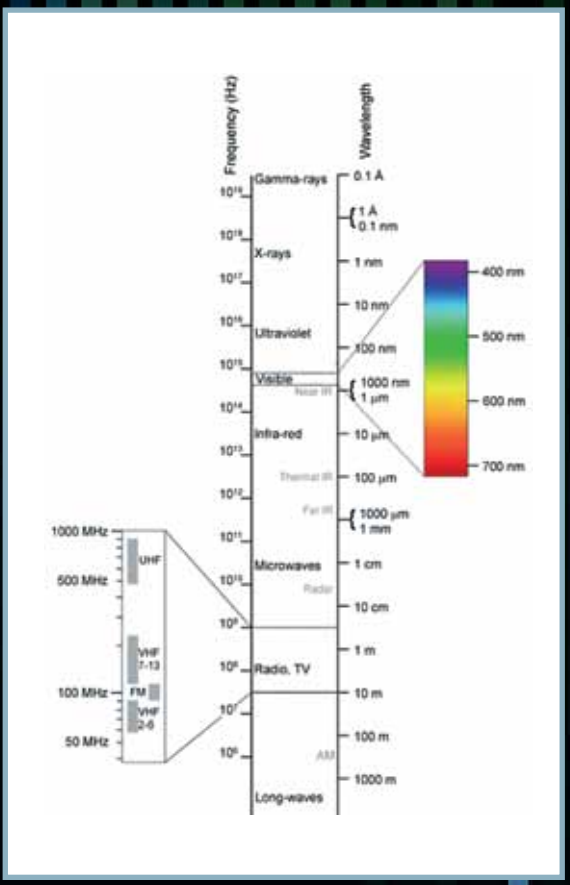
Key words
spectroscopy
analysis
chemistry
element

Did you know?

Robert Bunsen invented his Bunsen burner not for heating laboratory equipment, but for use in flame tests and spectroscopy.

Many substances absorb light at one wavelength and emit it at another. We make use of this in many ways, for example in glow-in-the-dark stickers. Compounds can also absorb and emit radiation that we cannot see, such as infrared, microwave and ultraviolet radiation.

Finding out which radiation is absorbed and emitted provides a lot of useful information about a compound. This is called **spectroscopy**. It is used in a very wide variety of applications, from helping chemists to work out the structure of a new molecule they have made, to testing for drugs, forensics testing and quality control.



The electromagnetic spectrum. Radiation from any wavelength on the spectrum can be used to find out information about matter.

Case Study 1 Iodine in milk

Iodine is an essential part of a healthy diet as it is needed by the thyroid gland for making thyroid hormones but too much iodine can lead to thyroid disorders. Seafood, iodized table salt, milk and dairy products are common sources of iodine. It is important to find out precisely and reliably how much iodine is present in dairy products, even in low levels, to ensure people obtain adequate but not excessive amounts of this micronutrient.

A simple, precise and accurate automatic method for determining total iodine concentration in milk products based on atomic absorption spectrometry could improve studies of this essential micronutrient.

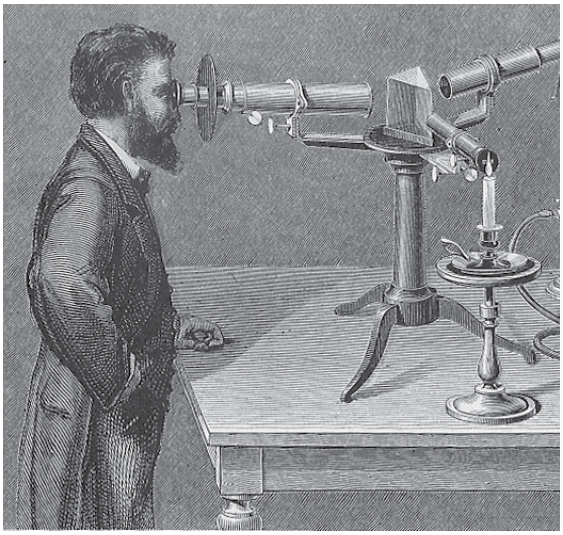
The method allows scientists to find out the concentration of total iodine in infant formulas and powder milk samples.

It is important to know exactly what is in formula milk for babies. Emission spectroscopy can help to identify the elements and compounds present.

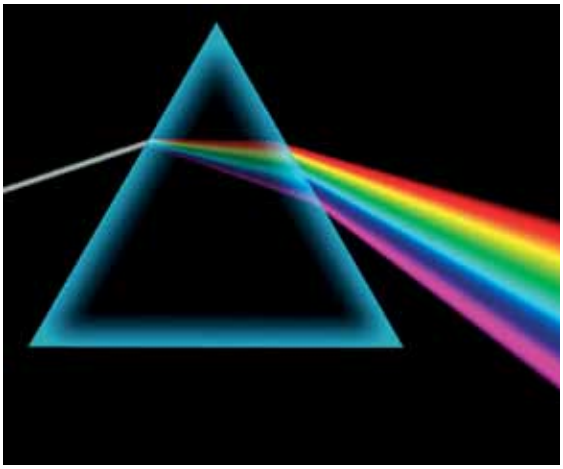
Emission spectroscopy

Spectroscopy began with the study of visible light spread out according to its wavelength by a prism or diffraction grating. This gives a spectrum or rainbow pattern. It was studied by Robert Bunsen (who invented the burner which bears his name) and Gustav Kirchhoff in the late 1850s.

Bunsen had observed that some elements give a coloured flame when they are heated – what we now know as the flame test. He was trying to use flame tests to analyse elements but found it was not accurate enough. Kirchhoff suggested to him that he use a spectroscopic method (to split up the light into a spectrum) rather than just the colours of the flames and this proved far more successful.



Gustav Kirchhoff working with his spectroscope. Note the prism used to split light up into a spectrum.



A prism splits white light into its different wavelengths – this is dispersion.

The emission spectrum of a chemical element or chemical compound is the spectrum of frequencies of electromagnetic radiation emitted by the element's atoms or the compound's molecules, in this case when they have been heated in a flame.

Each element's emission spectrum is unique. Therefore, spectroscopy can be used to identify the elements in matter of unknown composition.

Infrared spectroscopy

Infrared (IR) spectroscopy involves firing infrared radiation at a substance and measuring the radiation that is absorbed by the molecules. It is particularly useful for studying organic (carbon-containing) chemicals and has a huge range of applications.

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Case Study 2 Breath tests

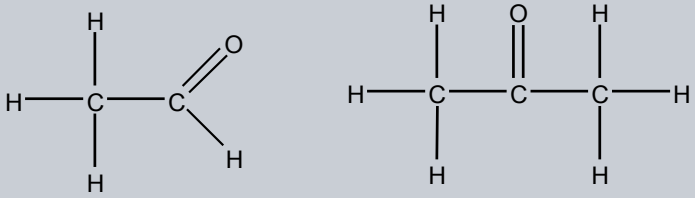
Trace chemicals can be detected in the breath using IR spectroscopy. This could open up a whole new area of medical diagnostics and health research.

The morning after eating, telltale odours of some foods such as onions and garlic can remain on the breath for many hours.

These smells are unpleasant but our breath can also carry other odours which are far more useful. Some diseases produce chemicals which are exhaled and it may be possible to use these for diagnosing those conditions. For instance, the presence of unusually large amounts of ethanal can be an indication of lung cancer; hydrogen cyanide may be detectable on the breath of cystic fibrosis sufferers with lung infections.

Using breath for diagnosis has the advantage that it is far more patient friendly than blood analysis, which involves insertion of a needle, or urine analysis, which some patients find embarrassing. It is much simpler simply to blow into a device.

Breath test diagnostics have been in development for many years, but researchers in the UK are now moving forward with a system that can detect propanone and other chemicals which are present at less than 10 parts per million. Propanone is produced during exercise when the body switches to so-called 'fat-burning' so this could be used in gyms to monitor how well a person has burned off body fat.

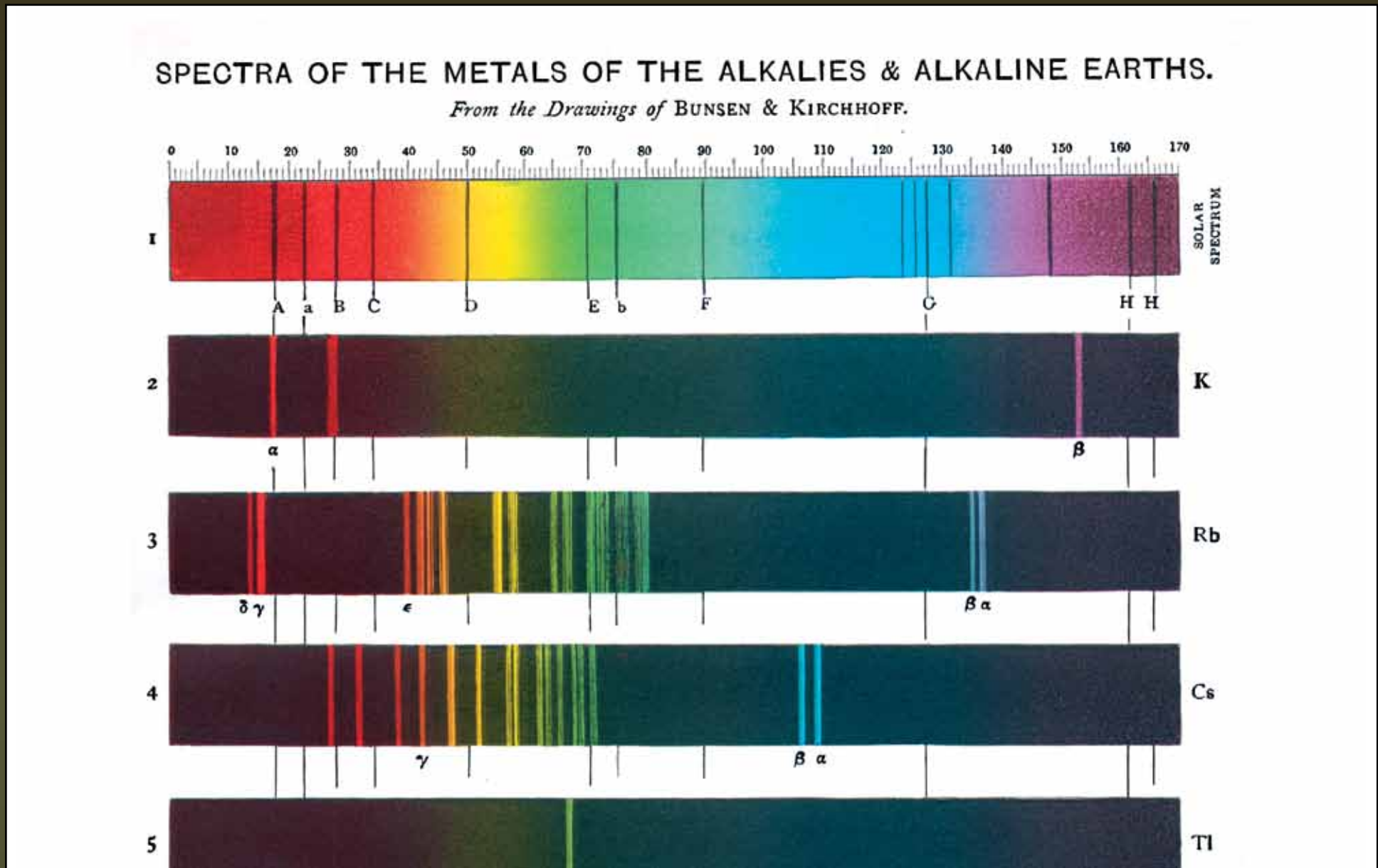


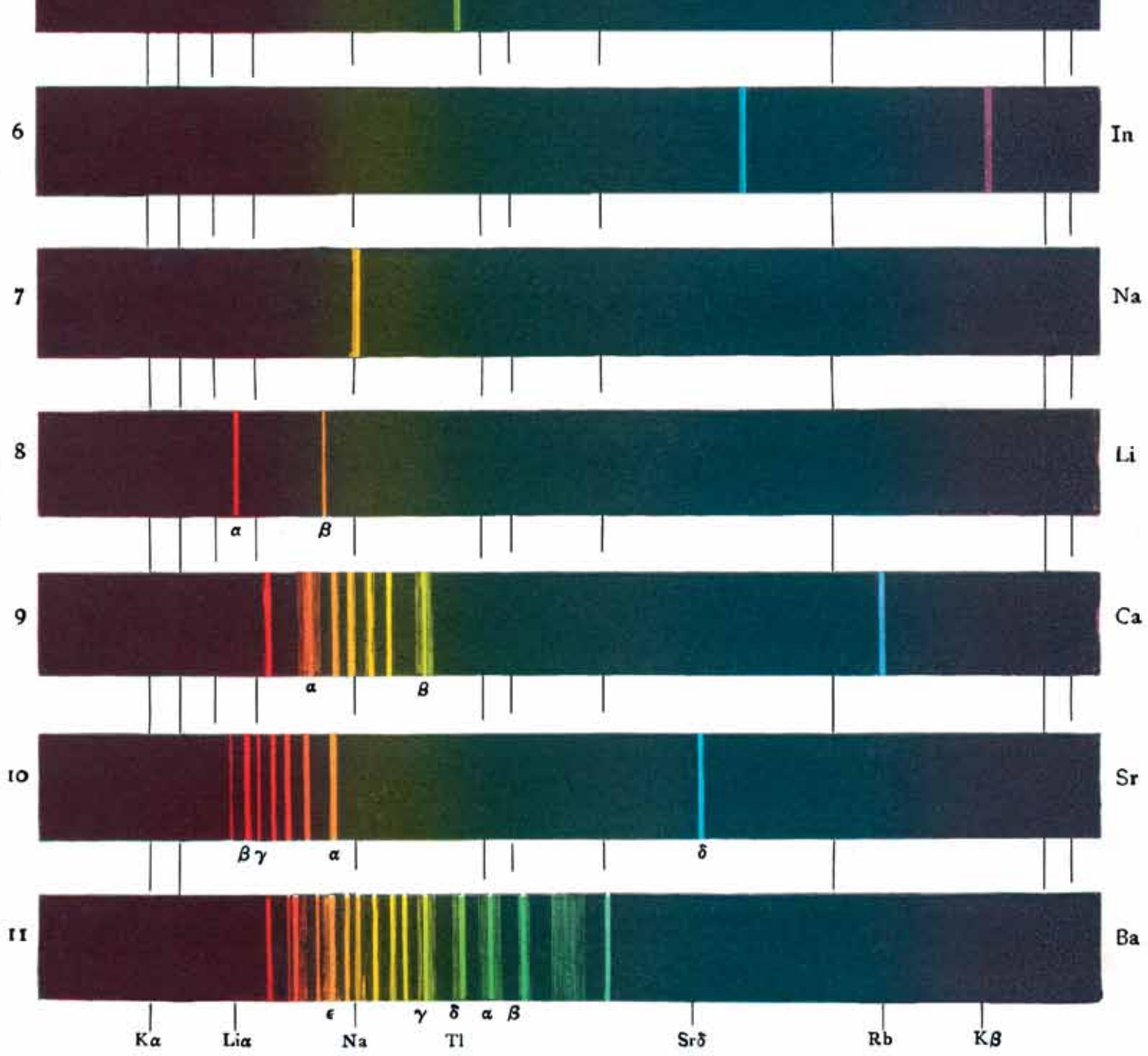
Ethanal Propanone

Most people would prefer to breathe into a tube than to have a blood test.

The Big Picture on pages 10-11 shows emission spectra of 11 different elements, as observed by Bunsen and Kirchhoff.

Flame emission spectra of the elements of the first two groups in the Periodic Table, as discovered by Bunsen and Kirchhoff.





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