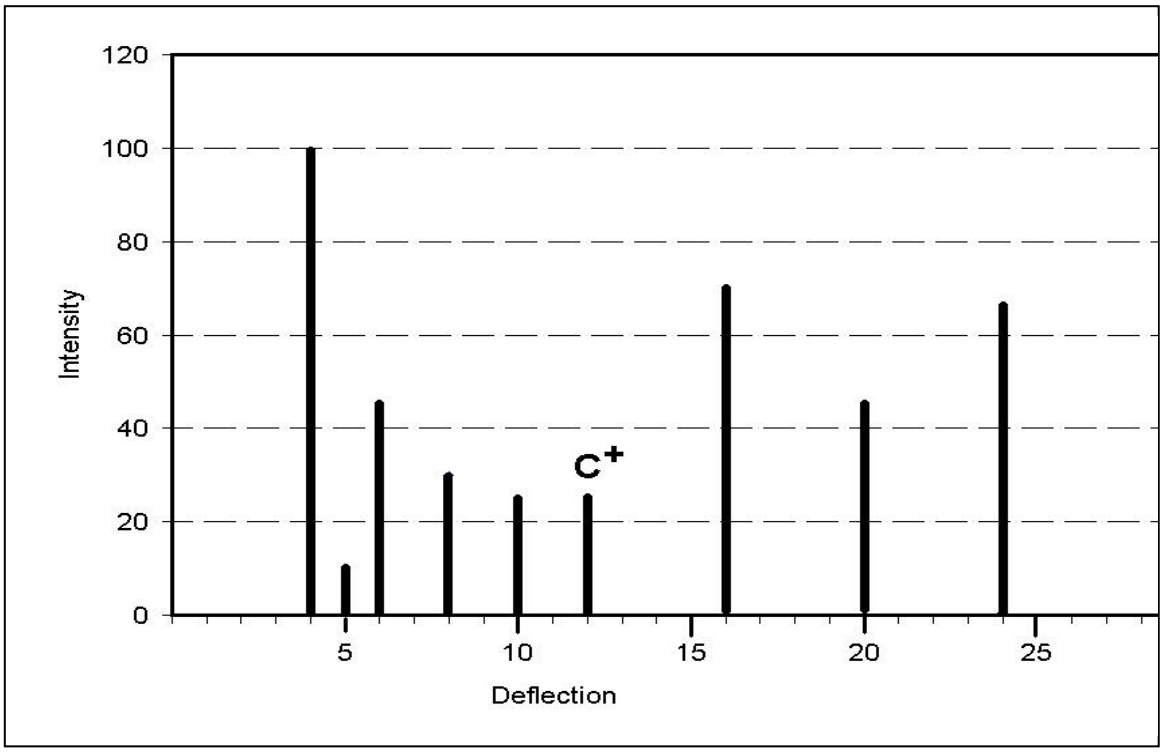
The IMAGE spacecraft uses an instrument called a mass spectrometer to identify the elements in the gases surrounding Earth, and trapped within Earth's magnetic field. The Detectives on the TV program CSI also use instruments like this to identify traces of substances found at the crime scene, or ingested by the victim. A mass spectrometer sorts out the atoms of matter by their mass. Scientists can then identify the kind of atom in the gas by their masses. Some instruments can detect a single atom from among trillions. Here's how the instrument works:

A mass spectrograph lets charged atoms (ions) pass through a magnetic field. As they travel, the ions are turned through a radius that depends on their mass and charge. Atoms with high masses are turned through a larger radius. Atoms with low mass are turned through a smaller radius. For example, in a hypothetical mass spectrometer, a helium ion, He+, with only one electron (a charge of 1 unit) might be turned through a radius of 4 units, and a helium ion, H++, with both electrons lost (a charge of 2 units) would be turned through a radius of only 2 units. An ion of carbon, C+, with 3 times the mass of a helium atom, and with one missing electron (a charge of 1 unit) would be turned through a radius of 4 units x 3 = 12 units.

Question 1: From the above example, what radius would a carbon atom with 2 missing electrons be turned through in this instrument? Symbol = C^{++}

Question 2: From the above example, what radius would an ion of magnesium, Mg+, with one missing electron be turned through?

With a copy of the periodic table of the elements, the clues above, and the mass spectrum below with its one identified ion, C^{+}, identify the other elements found by the mass spectrometer. Are you ready to join the CSI Team?



The IMAGE spacecraft uses an instrument called a mass spectrometer to identify the elements in the gases surrounding Earth, and trapped within Earth's magnetic field. An ordinary prism or 'diffraction grating' takes light and sorts it into a spectrum from red to blue. A mass spectrometer, such as the HENA, MENA and LENA instruments on IMAGE, sorts out the atoms of matter passing through its window by their mass and charge. The kind of data you get from this instrument looks very much like a spectrum plot in which the spectral 'lines' you would see in a light spectrum from individual atoms is replaced by 'lines' that represent the masses of the atoms themselves. Scientists can then identify the kind of atom in the gas directly by its mass, rather than the light it emits. Note: The formula relating the mass (M) and charge (Q) of the ion to its turning radius (R) looks like this:

$$\mathbf{R^2 = constant \times M / Q}$$

For example, in a hypothetical mass spectrometer, a helium ion with only one electron (Q= 1) might be turned through a radius of 4 units, and a helium atom with both electrons lost (a charge of Q=2) and written as He++ would be turned through a radius of 2 units. An atom of carbon with 3 times the mass of a helium atom, and with one missing electron (a charge of Q = 1) would be turned through a radius of 12 units. **Note: The 'units' are in terms of centimeters^2, but students don't have to know this to answer the questions.**

Question 1: From the above example, what radius would a carbon atom with 2 missing electrons (C++) be turned through in this instrument?
Answer: With one missing charge the radius is 12 units, with 2 missing electrons it will be 12 / 2 = 6 units.

Question 2: From the above example, what radius would an atom of magnesium with one missing electron be turned through?
Answer: Students will look up the atomic mass of magnesium and determine that it is twice the mass of a carbon atoms. Since, as for carbon, there is only one missing electron, Q=1, and so the radius is just 12 x 2 = **24 units.**