Spectroscopy

The investigation of electromagnetic radiation is of great importance both for physics and chemistry. It is used for revealing the structure of atoms, and for determination of elements which build matter. The simplest is the radiation of atoms which are sparse so that their interactions can be neglected (diluted monatomic gasses, metal vapors etc.) In that case the energy of an electron is determined only by the forces inside a single atom. Wavelength and hence frequencies of radiation caused by the transitions of electron from the higher to the lower energy level form discrete lines characteristic for given chemical element. The dependence of the radiation power on the wavelength or frequency is called the spectrum. In spectral analysis of simple samples it is sufficient to know the radiation in the visible part of spectrum, which is seen in spectrometer as a series of more or less intensive lines.

Atoms can be excited by heating in flame or by accelerating in an electric field. Emitted radiation can be separated by dispersion on prism or by diffraction on optical grating. If the spectrum is observed visually such instrument is called spectroscope. If the spectrum is recorded on a photographic plate the instrument is called spectrograph. If the instrument enables wavelength determination then it is called spectrometer. The optical scheme of spectroscope or spectrometer is given in Fig. 1.

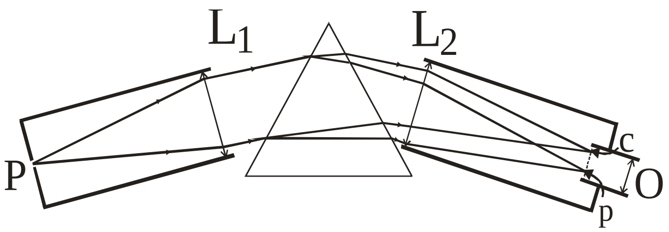

Figure 1.

P is a slit irradiated by investigated light. It is placed in the focal plane of the L_1 lens and is forming a collimator with it. The parallel light rays exiting the collimator are incident on a prism where they are separated into components. Depending on the wavelength they exit the prism in different angles (in the picture only two rays are drawn. The one for red is denoted by c, and the one for blue is denoted by p). Each component color is focused at a definite position, according to its wavelength, and forms a colored image of the slit in the focal plane of the lens L_2. The colored images are called spectral lines and are observed through an ocular O. The scale (or a pike) located in the focal plane of the lens L_2 is seen together with the spectrum so that each light wavelength corresponds to a single value on a scale.

Exercise 1.

Determine the wavelength in the spectrum of given source.

The source of light is a mercury lamp. In front of it is a glass plate which absorbs ultraviolet light and protects the observer. Place the lamp about 20 cm in front of the slit of the spectrometer so that it is well illuminated. Looking through the ocular the mercury spectrum is seen together with the pike. By turning the big knob with numbers on it, place each colored line on behind the pike and read the position on the knob S. Right down in your table the positions for all colors in the spectrum and using the computer program calculate the wavelength for each color.
Calculate the energy of photon (in eV) for each wavelength using equation:

$$E\left(eV\right) = \frac{1.24 \cdot 10^{-6}}{\lambda(m)}$$

Exercise 2.
Determine the constant of elasticity for the iodine I_2 molecule.

Heat the flask with iodine so it begins to evaporate and becomes purple. Place it in front of the spectrometer's slit. Shine it with the lamp from the behind. Through the ocular you will see a series of black separated lines inside a wide colored band. Place the pike on one line and read S1. Several lines apart place again the pike on the line and read S2. Write down the number of lines that they are separated n. For each line calculate on the computer its wavelength, and then find its frequency ($\nu = c / \lambda$). Using the equations given in the results sheet, find the spring constant for the iodine molecule.