Z19 - Determination of Dissociation Energy of I_2 Molecule

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Main goal of the experiment is to determine a dissociation energy of iodine molecule $I2$. The method is based on a measurement of $I2$ absorption spectrum in the visible range of the spectrum. The experiment consists of three stages: 1) calibration of the spectral apparatus (dispersion curve), 2) measurement of the absorption spectrum for different temperatures, 3) determination of dissociation energy based on obtained results.

Preparatory questions

- absorption and emission spectra of molecules [1, 3],
- energy structure of di-atomic molecules: rotational and vibrational levels, electronic energy states [1, 3],
- Boltzmann law, population of energy levels and theirs influence on the absorption spectrum [1, 3],
- electronic and vibrational transitions - Franck-Condon principle [2],
- wavefunctions for different vibrational levels, Franck-Condon coefficients [2],
- determination of dissociation energy - Birge-Sponer plot approximation [2],
- monochromator: principle of operation; SPM-2 monochromator (spectral resolution, aperture, luminosity, normal slit-width); diffraction grating - principle of operation [2],
- photomultiplier: principle of operation, spectral efficiency and its influence on the measured spectra [3].

Computational assignments

1. Absorption spectrum of I_2 molecule occurs in the $400 - 645nm$ range. Express the spectral range in angstroms [Å], and in reciprocal centimetres $[cm^{-1}]$. Justify the calculations using appropriate formulas.
2. Using an anharmonic oscillator approximation, calculate the dissociation energy D_0, having oscillation frequency $\omega e = 15cm^{-1}$ and anharmonicity $\omega_e x_e = 0.5cm^{-1}$.

Apparatus and materials

Scheme of the experimental apparatus is shown in Fig. 1. Student has in his/her disposal the following apparatus:

- iodine cell closed in an oven,
- oven power supply with temperature regulator,
- halogen lamp with power supply,
- calibration spectral lamp (filled with Hg and Cd) with power supply,
- focusing lens,
- beamsplitter plate,
- grating monochromator,
- diffraction grating drive,
- photomultiplier integrated with high voltage power supply,
- photomultiplier signal amplifier,
- PC card with A/D converter,
- PC equipped with dedicated program for data acquisition.

Experiment

- getting familiar with the experimental set up, experimental procedure and program for data acquisition,
- measuring spectrum of calibration spectral Hg-Cd lamp,
- determination of a dispersion curve for the monochromator diffraction grating,
- measuring spectrum of the halogen lamp,
- measuring of $I2$ absorption spectra for several temperatures (e.g., room temp., 40^0C, 50^0C, 60^0C),

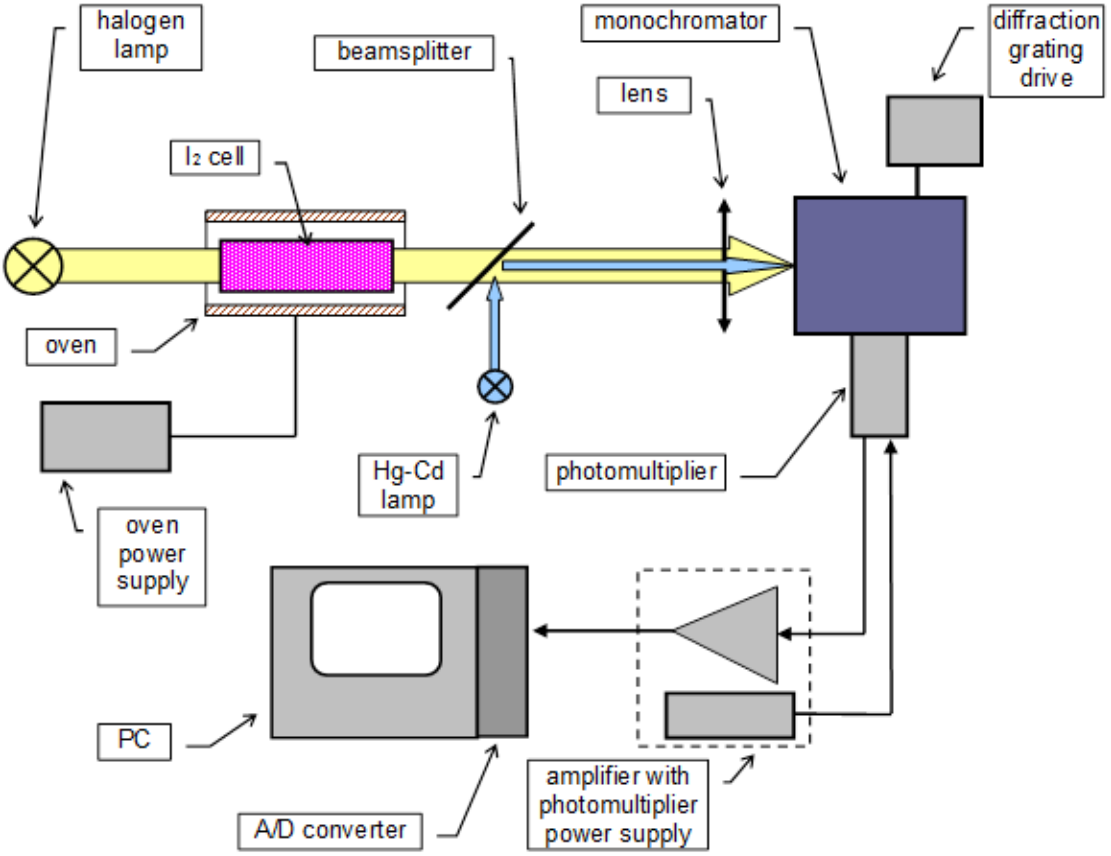

Figure 1: Experimental apparatus

Data analysis

For each of the recorded absorption spectrum:

- draw the Birge-Sponer plot,
- determine energy W,
- calculate dissociation energy D_0 of I_2 molecule excited and ground states,
- estimate an error in the D_0 determination,
- compare determined dissociation energy with a table value.

Safety rules

In order to avoid getting burnt, do not touch a halogen lamp and oven that is used for heating the iodine cell.

References

[1] J.M. Hollas, *Modern Spectroscopy*, John Wiley & Sons 2004, Chapter 7.2.5.

[2] Manual of the experiment Z19

[3] W. Demtroeder, *Laser Spectroscopy*, Springer, 2003, Chapter 4.5.4.