JCE WebWare: Web-Based Learning Aids

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The van der Waals Equation of State and the Law of Corresponding States: A Spreadsheet Experiment

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In typical physical chemistry courses the student is told how the van der Waals equation works *(1, 2)*. The mathematics needed for making a Maxwell construction is difficult for the average chemistry student (what is needed are the roots of a cubic polynomial *(3)*). This makes it difficult to show how the liquid–gas phase diagram is obtained from the equation of state.

Here a spreadsheet experiment is presented that can be used to illustrate various aspects of the van der Waals equation of state. With this spreadsheet the students are able to play around with the van der Waals equation so that they can see how this equation works. Together with this spreadsheet, supporting material is presented that includes a set of questions that enable the students to study actively these topics:

1. The critical pressure, temperature and volume
2. The difference between isotherms of the ideal gas and the van der Waals fluid at high temperatures
3. The van der Waals loop
4. The Maxwell construction and the coexistence curve in the p–v phase diagram
5. The Maxwell construction and the liquid–vapor line in the p–T phase diagram
6. The Law of Corresponding States
7. A comparison of the predictions of the van der Waals equation to experimental data

In order to answer the questions presented in the supporting material, the students have to make their own plots.

This spreadsheet experiment can be used as an integrated part of a physical chemistry course that includes lectures, experiments, and workgroups. Typically the students, working in groups of 2, need approximately 2 to 2.5 hours (break included) to answer the questions. This spreadsheet is also suitable for self-study.

This spreadsheet is designed for Excel. It runs also on OpenOffice spreadsheet Calc (version 2.0).

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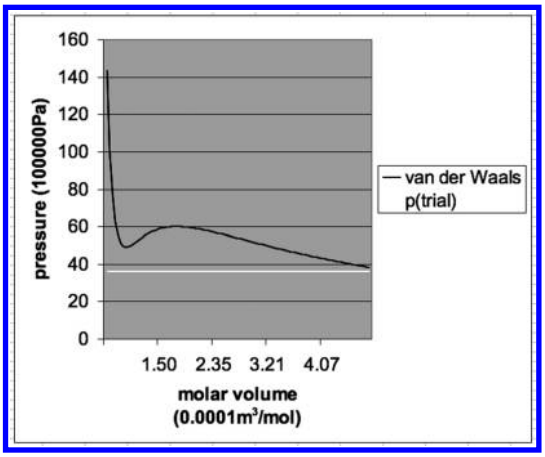

The dark line is the van der Waals curve of ethane at T = 304.2 K, generated by the spreadsheet. By adapting the height of the white horizontal line, p(trial), it is possible to perform a Maxwell construction to determine the coexisting phases.