

Reading assignment for the course “ Special Topics in Material Science”

“ Thermodynamics” (H.J. Kreuzer and I.Tamblyn, World Scientific Pub Co, 2010)

In the first part of the course “ **Special Topics in Material Science**” we will focus on Colloids and Self Assembly, both subjects requiring a basic knowledge of thermodynamics, kinetics and statistics. The reading assignment is thus intended to remember the basic theorems of thermodynamics and to remind you how versatile this knowledge is; not only to explain many phenomena in material science, but also to understand the natural world around us. The book chosen for refreshing your knowledge is entertaining and easy to read, it not only has very instructive examples, but also gives short biographies of famous scientists and explains how some fundamental laws were discovered.

You are encouraged to form small teams (2-4 students) to help each other. Read the whole book, but as a minimum read Chapters 1-6 and – to make you understand the world around you a little better - chapter 8. It will be necessary to consult the library and other books to get the details, and this will prepare you for the course in which library studies (not online searches) will be an important part. The individual written “knowledge test” on October 27 will be on the minimum reading material.

To test yourself if you know some of the basics of thermodynamics, I recommend you answer the following questions (in your own words). This “homework” is voluntarily and if you write up the answers (no Wikipedia, no copy-and-paste!) and send them to me (michael.grunze@urz.uni-heidelberg.de) by Oct 20, I will correct them and return them to you on Oct 27.

- 1) Explain in your own words the arguments, which lead to the ideal gas law.
- 2) Isothermal compressibility and thermal expansion coefficient: how do they change with temperature? Sketch the dependence as a function of temperature for a ideal gas and a real gas
- 3) Explain how to measure temperature by
magnetic susceptibility
Electromagnetic force
- 4) Calculate the vibrational frequency of an argon atom in solid argon at 10 K (it behaves like a harmonic oscillator).
- 5) Draw the phase diagram of water and indicate and *define and discuss* the
Triple point
Critical point
Freezing point
- 6) Discuss the transition line between the liquid and the solid phase in the phase diagram of water. What happens if you increase the pressure?
- 7) How can you measure the temperature of the surface of the sun?

- 8) Why is the hole in a “black box” black?
- 9) Describe the mean squared velocity of an ideal gas (He) as a function of temperature and plot the result.
- 10) What will thermodynamics do for you as a material scientist? Where will you and where can you use it in your work?
- 11) You see a lightning and hear the thunder 15 seconds later. How far was the lightning away from you?
- 12) Explain the mechanical model of Feynman for the first and second law of thermodynamics
- 13) Explain “degeneracy” for a crystal made up of (otherwise identical) red and blue balls and the consequences for the entropy of the crystal at absolute zero. What is the name of this extra entropy contribution?
- 14) What is an extensive and what is an intensive variable? Give examples
- 15) Formulate the thermodynamic equilibrium between a) water and water vapor and b) a 1 normal NaCl solution and the vapor phase using the chemical potentials. How does the vapor pressure of water depend on the ion concentration in the solution? Plot the result in a phase diagram.
- 16) Plot the heat capacity C_v (in units of R) as a function of temperature (up to the dissociation temperature) for a) a monoatomic gas, b) for a diatomic gas, and c) CO_2
- 17) Explain a) contour length, b) persistence length, and c) wormlike chain model for a polymer.
- 18) Show how you can derive the entropy for an adsorbed gas (monatomic) on a surface using the Clausius-Clapeyron equation.
- 19) How does the vapor pressure of a small droplet change with radius? Is there a minimum size of a droplet? (look up Gibbs Free Energy of nucleation)
- 20) How can you predict the potential intensity (maximum wind speed) of a tropical cyclone?
- 21) Does the efficiency of a steam engine change with the temperature of the steam and the temperature of the surrounding (winter or summer)? Explain your answer.
- 22) Write a short essay on how you see your future as a scientist and how you want to achieve your professional goals. This will help me to understand you better.
- 23) Comment the attached pictures. What is your conclusion?

