Mid session test 2002
Thermal Physics 2060
Time: 1 hour.
Total number of questions **2**. Answer all the questions.

Question 1

Consider van der Waals equation of state $\left(P + \frac{a}{v^2}\right)(v - b) = RT$.

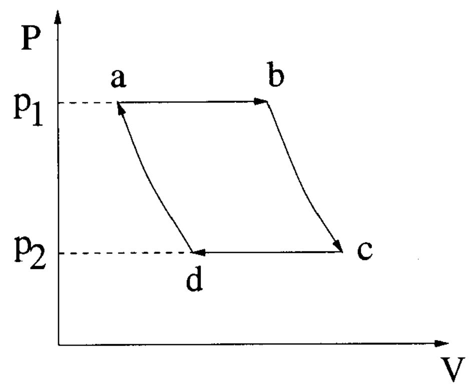
a. (4 marks) Sketch van der Waals *isotherms* (lines $T = const$) on the $P - V$-diagram. Clearly indicate the regions corresponding to the gas phase, the liquid phase, and the mixed state. Clearly indicate the critical point.

b. (3 marks) Sketch van der Waals *isotherms* on the $P - T$-diagram. Clearly indicate the regions corresponding to the gas phase and the liquid phase. Clearly indicate the critical point. Where is the mixed state on this diagram?

c. (3 marks) Derive an expression for the *isothermal* compressibility of an **ideal** gas. The compressibility is defined as $k = -\frac{1}{V}\left(\frac{\partial V}{\partial P}\right)_T$. Express your answer in terms of pressure and appropriate constants.

Question 2

An ideal gas is cycled through: Isobaric expansion from a to b, adiabatic expansion from b to c, isobaric compression from c to d, adiabatic compression from d to a.



a. (4 marks) (i) Clearly indicate on the diagram at which parts of the cycle the heat flows in and out of the system. (ii) How the work W done in the cycle is related to influx and outflux of the heat? (iii) Give definition of thermal efficiency η of the cycle.

b. (6 marks) Derive an expression for the thermal efficiency η in terms of P_1 and P_2.
You may use without proof the relation $PV^\gamma = const$ for the adiabatic processes and the fact that the heat capacity C_p is independent of temperature.
Hint: it is convenient to introduce temperatures T_a, T_b, T_c, T_d and volumes V_a, V_b, V_c, V_d corresponding to points a, b, c, and d, and then exclude temperatures and volumes from the expression for η