Assignment 1

1 Process $P = AT^b$

A process on an ideal gas is defined by

$$P = AT^b.$$

Express this process in terms of (P, V) and (V, T). Calculate compressibility and thermal expansivity in this process. What is the limitation on b? For which values of b this process becomes a known process? Find adiabatic values of the two thermodynamic coefficients above.

2 Work and heat in the $P = AT^2$ process

A process on an ideal gas is defined by

$$P = AT^2, \qquad A = \text{const}.$$

Calculate the received work and heat upon changing the temperature from T_1 to T_2. Assume $C_V = \text{const}$.

3 Heat capacity in the process $P = AT^b$

Calculate the heat capacity in the process

$$P = AT^b$$

of an ideal gas, expressing it as a function of T. Analyze different cases of b.

4 Van der Waals gas

Van der Waals equation of state for a non-ideal gas describing its transition to liquid has the form

$$\left(P + \frac{a}{V^2}\right)(V - b) = \nu RT,$$

where a describes attraction of the gas molecules and b describes the volume occupied by the molecules and thus excluded from their motion.

1. Using a plotting program or by hand, plot isotherms of this gas for different T, setting $a = b = \nu R = 1$. At high T isotherms are close to those for an ideal gas but for lower T they become distorted. Finally at some $T = T_c$ (critical temperature) the isotherm becomes horizontal at some point called "critical point", where its second derivative also turns to zero.
2. Calculate the isothermal compressibility of the van der Waals gas in terms of (V, T). Obtain its high-temperature limit. What happens with it at the critical point?
3. Find the critical point parameters using the analysis in (1.) as a hint.

5 Isochore-isotherm cycle

Find the efficiency of a heat machine using a isochore-isotherm cycle of an ideal gas.