Homework 2

Problem 1.9 of Pathria and Beale

1–28. Derive the thermodynamic equation
\[ C_p - C_v = \left[ p + \left( \frac{\partial E}{\partial V} \right)_T \left( \frac{\partial V}{\partial T} \right)_p \right] \]
and evaluate this difference for an ideal gas and a gas that obeys the van der Waals equation.

1–30. Derive the equation
\[ dE = \left[ T \left( \frac{\partial p}{\partial T} \right)_V - p \right] dV + C_v dT \]
and from this show that \( (\partial E/\partial V)_T = a/V^2 \) for a van der Waals gas.

1–29. Derive the thermodynamic equation of state
\[ \left( \frac{\partial E}{\partial V} \right)_T - T \left( \frac{\partial p}{\partial T} \right)_V = -p \]

1–35. It is illustrated in Chapter 17 that the speed of sound \( c_0 \) propagated through a gas is
\[ c_0 = (m \rho \kappa_s)^{-1/2} \]
where \( \kappa_s \) is the adiabatic compressibility
\[ \kappa_s = -\frac{10}{V} \left( \frac{\partial V}{\partial p} \right)_s \]
Show that this is equivalent to
\[ c_0 = \sqrt{\frac{\gamma}{M}} \left( \frac{\partial p}{\partial V} \right)_T \]
where \( \gamma = C_p/C_v \), and \( M \) is the molecular weight of the gas. Using the above result, show that
\[ c_0 = \left( \frac{\gamma RT}{M} \right)^{1/2} \]
for an ideal gas.