Homework 2

Problem 1.9 of Pathria and Beale

1–28. Derive the thermodynamic equation

$$C_p - C_V = \left[p + \left(\frac{\partial E}{\partial V}\right)_T\right]\left(\frac{\partial V}{\partial T}\right)_p$$

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 κ_S is the adiabatic compressibility

$$\kappa_S = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_S$$

Show that this is equivalent to

$$c_0 = V\left\{-\frac{\gamma}{M}\left(\frac{\partial p}{\partial V}\right)_T\right\}^{1/2}$$

where $\gamma = C_p/C_V$, and M is the molecular weight of the gas. Using the above result, show that

$$c_0 = \left(\gamma\frac{RT}{M}\right)^{1/2}$$

for an ideal gas.