The following are a set of thermodynamic identities,

\[
\begin{align*}
\left(\frac{\partial T}{\partial P}\right)_S &= TV\frac{\alpha_p}{C_p} \quad (1) \\
\left(\frac{\partial T}{\partial P}\right)_H &= -\frac{1}{C_p}\left(\frac{\partial H}{\partial P}\right)_T \quad (2) \\
C_v &= T\left(\frac{\partial S}{\partial T}\right)_V \quad (3) \\
\left(\frac{\partial S}{\partial V}\right)_T &= \left(\frac{\partial P}{\partial T}\right)_V \quad (4) \\
C_p(\kappa_T - \kappa_S) &= TV\alpha_p^2 \quad (5) \\
\rho\left(\frac{\partial \mu}{\partial \rho}\right)_T &= \left(\frac{\partial P}{\partial \rho}\right)_T \quad (6) \\
\left(\frac{\partial (1/T)}{\partial P}\right)_H &= \frac{1}{T^2C_p}\left(V - T\left(\frac{\partial V}{\partial T}\right)_P\right) \quad (7) \\
\left(\frac{\partial H}{\partial T}\right)_V &= C_p\left(1 - \frac{\alpha_{\mu JT}}{\kappa_T}\right) \quad (8) \\
\left(\frac{\partial A}{\partial P}\right)_S &= V\left(\frac{\kappa_T P}{\gamma} - \frac{\alpha_p TS}{C_p}\right) \quad (9) \\
\left(\frac{\partial A}{\partial V}\right)_S &= \frac{\alpha_p TS}{\kappa_T C_v} - P \quad (10) \\
C_p &= C_v + T\left(\frac{\partial V}{\partial T}\right)_P\left(\frac{\partial P}{\partial T}\right)_V \quad (11) \\
\frac{C_p}{C_v} &= \frac{\kappa_T}{\kappa_S} \quad (12) \\
\left(\frac{\partial E}{\partial P}\right)_T &= V(\kappa_T P - \alpha_p T) \quad (13)
\end{align*}
\]

where \(\alpha_p\) is the coefficient of thermal expansion, \(\kappa_T\) is the isothermal compressibility, \(\kappa_S\) is the adiabatic compressibility (S held constant), \(\gamma = C_P/C_v\) and \(\rho = n/V\).

Eqs(1-10) are for your benefit. Eqs(11-13) are the challenge problems. To receive credit, you will derive Eqs(11-13) to an audience of me in room 104. The maximum time allowed is 15 minutes for all three proofs. No assistance will be provided and you are not allowed to use paper, notes, books etc. We wish to see you derive these on your own. The last day for presentations is Friday 5 May (5’th week) at 3 pm. Proof times are my office hours.