

Beginning with the fundamental thermodynamic relation, and the definition of  $C_v$ ,

$$TdS = dE + PdV - \mu dN, \quad C_v = T \left( \frac{\partial S}{\partial T} \right)_{N,V}$$

derive the equality

$$\left( \frac{\partial C_v}{\partial V} \right)_{T,N} = T \left( \frac{\partial^2 P}{\partial T^2} \right)_{V,N}$$