Freie Universität Berlin
Fachbereich Physik
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Statistical Physics and Thermodynamics (SS 2016)

Problem Sheet 10

Hand in:Thursday, June 30th during the lecture

http://www.physik.fu-berlin.de/en/einrichtungen/ag/ag-netz/lehre/

1. Heat Capacities (12 points)

The specific heat capacities C_P and C_V can be expressed in terms of temprature T, Volume V, isothermal compressibility $\kappa_T = -V^{-1}(\partial V/\partial P)_T$, thermal expansivity $\alpha = V^{-1}(\partial V/\partial T)_P$ and adiabatic compressibility $\kappa_S = -V^{-1}(\partial V/\partial P)_S$. In the lecture we obtained the following expression for TdS in terms of C_V:

$$TdS = C_V dT + \frac{\alpha T}{\kappa_T} dV$$

a) Show that you can express TdS in terms of C_P as the following:

$$TdS = C_P dT - \alpha T V dP$$

(4 points) (**Hint**: Write down the total differential of $U(P,T)$ and $V(P,T)$ and plug them in the equation $TdS = dU + PdV$)

b) Using these results prove that

$$C_P - C_V = \frac{\alpha^2 T V}{\kappa_T}$$

(3 points)

c) Express C_P and C_V in terms of T, V, α, κ_T and κ_S. **(3 points)**

d) Show whether C_P is equal, less or greater that C_V. Do the same for κ_T and κ_S. **(2 points)**

2. Thermodynamic Relations (8 points)

Prove the following useful thermodynamic relations:

a) $\left(\partial N/\partial \mu\right)_{T,V} = \frac{N^2 \kappa_T}{V}$, where μ is the chemical potential.**(4 points)** (**Hint**: Begin with writing down the Gibbs-Duhem equation $N d\mu = -SdT + VdP$)

b) $\left(\partial T/\partial P\right)_H = \frac{[T\alpha - 1]V}{C_P}$ **(4 points)**