1. A sample of air occupies 1.0 L at 25℃ and 1.00 atm. What pressure is needed to compress it to 100 cm^3 at this temperature? (10%)

2. Show that $(\partial p/\partial T)_V = \alpha/\beta$, where $\alpha = 1/V(\partial V/\partial T)_p$ is the coefficient of thermal expansion and $\beta = -1/V(\partial V/\partial p)_T$ is the isothermal compressibility. (15%)

3. Calculate the entropy change of a sample of perfect gas when it expands isothermally from a volume V_i to a volume V_f. (15%)

4. The molar Gibbs energy of a certain gas is given by

$$G_m = RT\ln p + A + Bp + \tfrac{1}{2}Cp^2 + \tfrac{1}{3}Dp^3 \qquad (15\%)$$

where A, B, C, and D are constants. Obtain the equation of state of the gas.

5. Find the expression for the fugacity coefficient of a gas that obeys the equation of state

$$\frac{pV_m}{RT} = 1 + \frac{B}{V_m} + \frac{C}{V_m^2} \qquad (15\%)$$

where the fugacity coefficient of a gas is given by

$$\ln\phi = \int_0^p \left(\frac{Z-1}{p}\right)dp$$

where Z is the compression factor of the gas.

6. Please derive the Gibbs-Duhem equation for a two-component mixture as follows

$$n_A d\mu_A + n_B d\mu_B = 0 \qquad (15\%)$$

7. Show that two phases are in thermal equilibrium only if their temperatures are the same. (15%)

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