Assignment 5

PHY 202
Heat and Thermodynamics

Isothermal Compression

Consider a hydrostatic system maintained at constant temperature and particle number and quasi-statically compressed from an initial pressure P_i to final pressure P_f . Calculate the change in entropy and internal energy in terms of the material parameters. Use the ideal gas equations

$$U = \frac{3}{2} N k_{\mathrm{B}} T \qquad\qquad PV = N k_{\mathrm{B}} T$$

to compute these quantities.

A system has the fundamental relation given by

$$S(U,V,N) = Nk_{\mathrm{B}} \ln\left[\frac{5}{2} + \frac{U^{3/2}V}{\kappa N^{5/2}}\right]$$

Calculate the heat extracted and the change in the internal energy during an isothermal compression from an initial pressure P_i to final pressure P_f .

The equation of state for a system is given by

$$P\left(v + \frac{A}{T^2}\right) = RT$$

One mole of the system is expanded isothermally from an initial pressure P_0 to a final pressure P_f. Calculate the heat exchanged.

A system is expanded along a straight line in the *P-v* plane from an initial state (v_0, P_0) to the final state (v_f, P_f) . Calculate the heat transfer per mole to the system in this process. It is assumed that the expansion coefficient, isothermal compressibility and specific heats are known only along the isochore $v=v_0$ and the isobar $P= P_f$

$$\frac{c_v \kappa_T}{\alpha} = AP \qquad \text{for } v = v_0$$

$$\frac{c_p}{v\alpha} = Bv \qquad \text{for } P = P_f$$

The equation of state of a matter is given by

$$p = AT^3/V$$

where the symbols have their usual meaning and *A* is a constant. The internal energy of the system is given by

$$U = BT^n \ln\left(\frac{V}{V_0}\right) + f(T)$$

where *B*,*n* V_0 are constants and *f(T)* depends only on temperature. Determine *B* and *n*.

The tension in an ideal cylinder is given by

$$F = aT\left(\frac{L}{L_0(T)} - \frac{L_0(T)^2}{L^2}\right)$$

where *a* is a constant, L_0 is the length at zero tension and *L* is a function of temperature only.

The cylinder is stretched reversibly and isothermally to twice its initial length. Find the heat transferred to the cylinder in terms of *a*, *T*, L_0 and α_0 , where α_0 is the thermal expansion coefficient at zero tension.

When the cylinder is stretched adiabatically, its temperature changes. Calculate the infinitesimal change in temperature.

For a Van-der Waals gas with an equation of state

$$P = \frac{k_{\mathrm{B}}T}{V-b} - \frac{a}{V^2}$$

Calculate the change in internal energy during an isothermal process.