Chemical Engineering Thermodynamics (CH2010)

Assignment Questions

1) For an ideal gas, show that $C_p = C_v + R$

2) Using the van der Waals equation, fi nd an expression for the derivative, $\left(\frac{\partial h}{\partial T}\right)_s$ using a,b, R, C_v and T.

3) Develop a general relationship for the change in temperature with respect to pressure at constant entropy $\left(\frac{\partial T}{\partial P}\right)_s$

(a) Evaluate the expression for an ideal gas.

(b) From the result in part (a), show that for an ideal gas with constant C_p, an isentropic expansion from state 1 and state 2 yields Equation $PV^{\Gamma} = constant$

(c) Evaluate the expression for a gas that obeys the van der Waals equation of state.

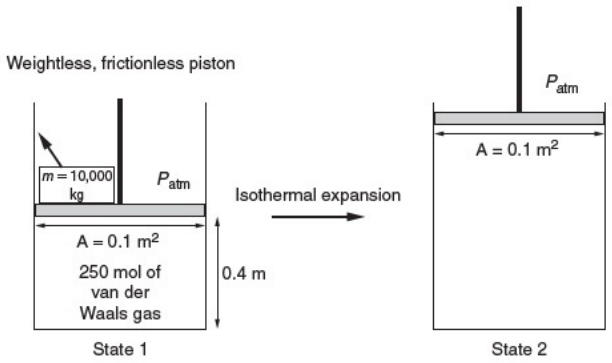
4) Consider the piston-cylinder assembly shown below; 250 moles of gas expand isothermally after the removal of a 10,000 kg block.

(a) What is the internal energy change for the expansion process?

(b) What is the entropy change of the universe for this process?

Assume that the PvT behavior can be described by the van der Waals equation with

$a = 0.5[Jm^3/mol^2]; b = 4x10^{-5}mol/m^3$; and that the ideal gas heat capacity has a constant value of $C_p^{ideargas} = 35J/(molK)$.



5) One mole of CO is initially contained on one-half of a well-insulated, rigid tank. Its temperature is 500 K. The other half of the tank is initially at vacuum. A diaphragm separates the two compartments. Each compartment has a volume of 1 L. Suddenly, the diaphragm ruptures. Use the van der Waals equation for any nonideal behavior. Answer the following questions:

(a) What is C_v at the initial state?

(b) Do you expect the temperature to increase, decrease, or remain constant. Justify your answer with molecular arguments. Be specifi c about the nature of the forces involved.

(c) What is the temperature of the fi nal state?

(d) What is the entropy change of the universe for this process?

6) Consider fi lling a gas cylinder with ethane from a high-pressure supply line. Before fi lling, the cylinder is empty (vacuum). The valve is then opened, exposing the tank to a 3-MPa line at 500 K until the pressure of the cylinder reaches 3 MPa. The valve is then closed. The volume of the cylinder is 50 L. For ethane, use the truncated virial equation of state, in pressure: $Z = \frac{PV}{RT} = 1 + B'P$ with $B' = -2.8x10^{-8}[m^3/J]$

(a) What is the temperature immediately after the valve is closed?

(b) If the cylinder then sits in storage at 293 K for a long time, what is the entropy change of the universe (from the original, unfilled state)?

7) Calculate the enthalpy and entropy change of C_2H_6 from a state at 300 K and 30 bar to a state at 400 K and 50 bar using departure functions.

8) Methane fl owing at 2 mol/min is adiabatically compressed from 300 K and 1 bar to 10 bar. What is the minimum work required?