ME 24-221
THERMODYNAMICS I

Solution to Quiz #3
September 29, 2000
Instructor: Dr. Murthy

Given: (a) Piston cylinder assembly: Carbon Dioxide
(b) State 1: m = 0.1 kg; P_1 = 0.738 MPa; T_1 = 1247.35°c
(c) State 2: P_2 = 0.1 Mpa
(d) 1-2 is isothermal process

To Find: Z_1 and Z_2 at the initial and final states respectively. Also W_{1-2}.

Solution: To find Z we use Figure D.1. We need P_r and T_r.
From Table A.2, we get the critical constants for Carbon Dioxide.

T_c = 304.1 K and P_c = 7.38 Mpa

$T_{r1} = T_1/T_c = (1247.5 + 273.15)/304.1 = 5$
$P_{r1} = P_1/P_c = 0.738/7.38 = 0.1$
$T_{r2} = T_{r1} = 5$ (Isothermal. Hence $T_1 = T_2$)
$P_{r2} = P_2/P_c = 0.1/7.38 = 0.01355$

From Fig. D.1, $\boldsymbol{Z_1 = 1}$
$\boldsymbol{Z_2 = 1}$

Since the compressibility factor in both the states is equal to unity, we can use ideal gas approximation at states 1 and 2.

$W_{1-2} = P_1V_1\ln(P_1/P_2)$ (Work done for an isothermal process)

Since ideal gas approximation is valid, $V_1 = (mRT_1)/P_1$
Where R is the specific gas constant for CO_2. From Table A.5,
R = 0.1889 kJ/kg-K

$V_1 = (0.1)(0.1889)(1520.5)/0.738*10^3) = 0.03892\ m^3$

$\boldsymbol{W_{1-2}} = (0.738*10^3)(0.03892)\ln(0.738/0.1) = \mathbf{57.4107\ kJ}$

Since work is positive, it is done *by* the system.