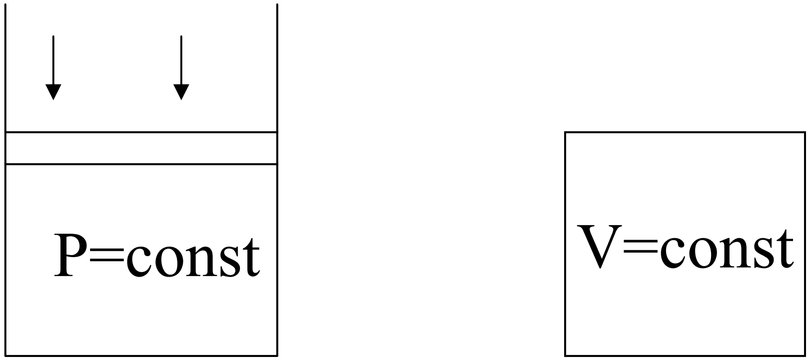
Problem Set 7, PS7 due Friday June 4

PS7-1 A rigid tank and a piston cylinder device both contain1.2 kmole of an ideal gas at the same temperature and pressure. The temperature of both container is raised by 15 C by adding heat. If the gas in the piston-cylinder is held at a constant pressure how much extra heat must be added to the piston-cylinder compared to the heat added to the tank?

PS7-2 25 ft^3 of nitrogen at 50 psia and 700 F is contained in a piston-cylinder device, The nitrogen in the piston-cylinder is cooled to 140 F while the pressure in the piston-cylinder remains constant. Determine the amount of heat transfer. Assume a specific heat at the average nitrogen temperature.

PS7-3 The piston of a piston-cylinder device rests on stops and has a mass such that a pressure of 400 kPa is required to lift the piston off the stops. The piston-cylinder initially contains 3 kg of air at 200 kPa and 27 C. The volume is doubled by adding heat. Determine a) the work done by the air, and b) the heat transferred. Sketch the process on a pressure-volume property diagram.

PS7-1



$$Q = m\,c_p\,\Delta T \qquad\qquad Q = m\,c_v\,\Delta T$$

$$\Delta Q = m\,c_p\,\Delta T - m\,c_v\,\Delta T$$

$$\Delta Q = m\,\Delta T\,(c_p - c_v)$$

$$\Delta Q = m\,\Delta T\,(R)$$

$$\Delta Q = 1.2\,\text{kmole} \times (15^{O}\,K) \times 8.314\,\frac{kJ}{kg^{O}K}$$

$$\Delta Q = 149.65\,kJ$$

PS7-2

$$m = \frac{p_1 V_1}{RT_1} = \frac{50\text{ psia} \times 144 \times 25\text{ ft}^3}{53.35 \times (700 + 460)} = 2.814\text{ lbm}$$

closed system

$$Q = \Delta E + W$$

$$Q = \Delta E + \int p dV = \Delta E + p \int dV$$

$$Q = m \times (u_2 - u_1) + m \times (pv_1 - p_2)$$

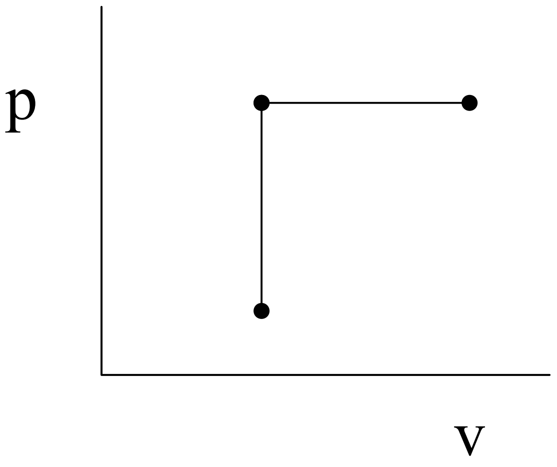
$$Q = m \times (u_2 + pv_2) - m(u_2 + pv_1)$$

$$Q = m(h_2 - h_1) = 2.814 \times .251 \times \left(700 - 140\right)$$

.215 is the c_p at 400F.

$$Q = 397\text{ BTU}$$

PS7-3



$$V_1 = \frac{mRT}{p} = \frac{3\times.28\times(273.15+27)}{200} = 1.292\ m^3$$

$$W = \int p dv = p_2(V_3 - V_2)$$

$$W = 400\ kPa(2\times1.292\ m^3 - 1.191\ m^3) = 516\ kJ$$

$$T_2 = T_1\left(\frac{p_2}{p_1}\right) = 300.15^O K\times2 = 600.3^O K$$

$$T_3 = T_2\left(\frac{V_3}{V_2}\right) = 600.3^O K\times2 = 1200^O C$$

$$Q = \Delta E + W$$

$$Q = m\times c_v(T_3 - T_1) + W$$

$$c_v @ 750^O K = .8$$

$$Q = 3\times.8\times(1200 - 300.15) + 516kJ = 2675\ kJ$$