ANNOUNCED QUIZ #1 – ME 3030 — Section 001 – Spring 2024

NAME: SOLUTION

This is an open book quiz. You may use a four function calculator. An unsigned honors pledge will result in a zero.

$\forall = 2.2\,m^3$

1. A rigid tank is initially completely evacuated (its absolute pressure is zero). A valve to the tank is opened and air from the surrounding environment rushes in. The surrounding environment is at a pressure of one atmosphere and a temperature of 300K. Heat transfer between the tank and its surroundings occurs so that the air in the tank is always at exactly 300K. After some time has passed, the pressure in the tank is at equilibrium with the outside air. Compute the heat transfer for the air in the tank. You may assume kinetic and potential energy effects are negligible.

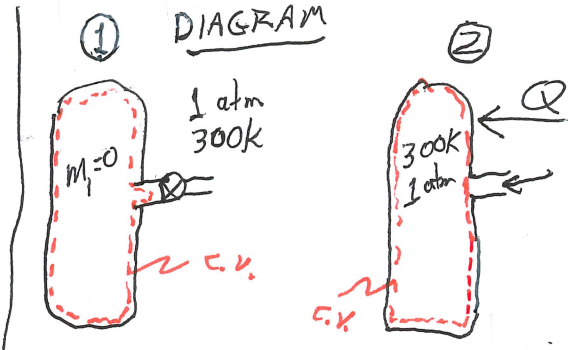
GIVEN: $T_{env}, P_{env}, T = 300K$ always, $P_f, T_f, m_i = 0, \forall$

FIND: $Q = ?$

ASSUME: No KE or PE effects; ideal gas behavior

ANALYSIS: Cons. of Energy for a control volume

DIAGRAM



$$\frac{dE}{dt} = \dot{Q} - \dot{W} + \sum_i \dot{m}_i\left(h_i + \frac{V_i^2}{2} + gz_i\right) - \sum_e \dot{m}_e\left(h_e + \frac{V_e^2}{2} + gz_e\right)$$

$E = KE + PE + U$

$$\frac{dU}{dt} = \dot{Q} + \dot{m}_i h_i \Rightarrow \int_1^2 dU = \int_1^2 \dot{Q}\,dt + \int_1^2 \dot{m}_i h_i\,dt \Rightarrow U_2 - U_1 = Q + h_i \int_1^2 \dot{m}_i\,dt$$

b/c const.

$$m_2 u_2 - m_1 u_1 = Q + h_i(m_2 - m_1) \rightarrow \boxed{Q = m_2(u_2 - h_i) = m_2(u(300k) - h(300k))}$$

Since I.G., $P_2\forall = m_2 R T_2$ $\quad m_2 = P_2\forall / RT_2$

$$R = \frac{\bar{R}}{MW} = \frac{8314\ J/kmol\cdot K}{28.97\ kg/kmole}$$

$$\boxed{R = 287.0\ J/kg\cdot K}$$

From A-22

$u(300K) = 214.07\ kJ/kg$

$h(300K) = 300.19\ kJ/kg$

$$m_2 = \frac{(101{,}325\,Pa)(2.2\,m^3)}{\left(287.0\frac{J}{kg\cdot K}\right)(300\,K)}$$

$$\boxed{m_2 = 2.589\ kg}$$

$$Q = (2.589\,kg)\left(214.07\frac{kJ}{kg} - 300.19\frac{kJ}{kg}\right)$$

$$\boxed{Q = -222.96\ kJ} \leftarrow \text{ANS}$$

I HAVE NEITHER PROVIDED OR RECEIVED HELP DURING THIS QUIZ.

SIGNATURE