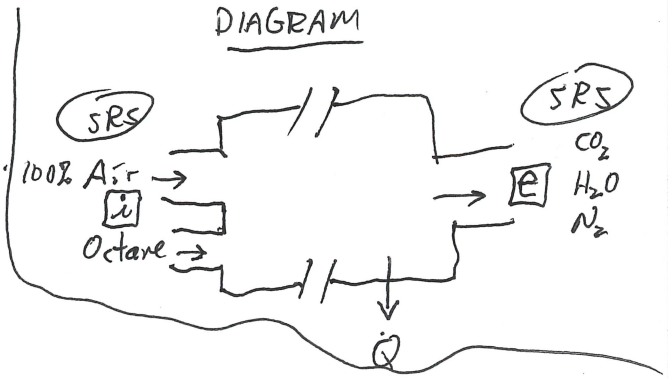
ANNOUNCED QUIZ #10 – ME 3030 — Section 001 – Spring 2024

NAME: SOLUTION

This is an open book quiz. You may use a 4-function calculator. An unsigned honors pledge will result in a zero.

1. Octane vapor and 100% theoretical air enter an uninsulated reactor at SRS. The reactor is sufficiently long, so that the exit is also at SRS. Determine the heat transfer rate in units of kJ per kmole of fuel flowing.

DIAGRAM



GIVEN: 100% theo air; octane; i, e @ SRS

FIND: $\dot{Q}/\dot{n}_F = ?$ kJ/kmole

ASSUME: Usual combustion assumptions, H_2O is vapor, S.S.

ANALYSIS: stoichiometry C_8H_{18}

$$C_8H_{18} + a(O_2 + 3.76N_2) \rightarrow b\,CO_2 + c\,H_2O + d\,N_2$$

C: $8 = b$

H: $18 = 2c$ $\quad c = 9$

O: $2a = 2b + c = 2(8) + 9 = 25$ $\quad a = 25/2$

N: $a(3.76)(2) = 2d$ $\quad d = 47$

$$C_8H_{18} + \frac{25}{2}O_2 + 47N_2 \rightarrow 8\,CO_2 + 9\,H_2O + 47\,N_2$$

(SRS) (SRS)

$$\bar{h} = \bar{h}^\circ_f + (\bar{h}(T) - \bar{h}(298K))$$

$\Delta\bar{h}$ → since i and e are at SRS, $\Delta\bar{h} = 0$ for everything

$$\frac{dE}{dt} = \dot{Q} - \dot{W} + \sum_i \dot{n}_i \bar{h}_i - \sum_e \dot{n}_e \bar{h}_e \qquad \dot{Q} = \sum_e \dot{n}_e \bar{h}_e - \sum_i \dot{n}_i \bar{h}_i$$

$$\dot{Q} = \left[\dot{n}_{CO_2}\bar{h}_{CO_2} + \dot{n}_{H_2O}\bar{h}_{H_2O} + \dot{n}_{N_2}\bar{h}_{N_2}\right]_{SRS} - \left[\dot{n}_F\bar{h}_F + \dot{n}_{O_2}\bar{h}_{O_2} + \dot{n}_{N_2}\bar{h}_{N_2}\right]_{SRS}$$

Divide by $\dot{n}_F$

$$\frac{\dot{Q}}{\dot{n}_F} = 8\bar{h}_{CO_2} + 9\bar{h}_{H_2O} - \bar{h}_F - \frac{25}{2}\bar{h}_{O_2} = 8\bar{h}^\circ_{f_{CO_2}} + 9\bar{h}^\circ_{f_{H_2O}} - \bar{h}^\circ_{f_{octane}} - \frac{25}{2}\bar{h}^\circ_{f_{O_2}}$$

$$\frac{\dot{Q}}{\dot{n}_F} = 8\left(-393{,}520\ \frac{kJ}{kmole}\right) + 9\left(-241{,}820\ \frac{kJ}{kmole}\right) - \left(-208{,}450\ \frac{kJ}{kmole}\right)$$

$$\frac{\dot{Q}_F}{\dot{n}_F} = -5{,}116{,}090\ kJ/kmole \leftarrow \text{ANS.}$$

I HAVE NEITHER PROVIDED OR RECEIVED HELP DURING THIS QUIZ.

SIGNATURE