a) $p_c = 125\,\text{atm} = p_{Tc}$ ($c_c \approx 0$ IN COMBUSTOR)

$T_c = 3000\,K = T_{Tc}$ ($c_c \approx 0$ IN COMBUSTOR)

$$\cancel{q}^{\,0} - \cancel{w_s}^{\,0} = \left(c_p T_e + \frac{c_e^2}{2}\right) - \left(c_p T_c + \frac{c_c^2}{2}\right)$$

$$c_p T_c + \cancel{\frac{c_c^2}{2}}^{\,0} = c_p T_e + \frac{c_e^2}{2} \qquad \text{ALSO } \left(\frac{p_e}{p_c}\right)^{\frac{\gamma-1}{\gamma}} = \frac{T_e}{T_c} \text{ SINCE}$$

q-s, ADIABATIC

$$\Rightarrow \quad c_e = \sqrt{2 c_p T_c \left[1 - \left(\frac{p_e}{p_c}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

$$= \sqrt{2(1500)(3000)\left[1 - \left(\frac{1}{125}\right)^{\frac{\gamma-1}{\gamma}}\right]} \qquad \gamma = 1.2$$

$$\boxed{c_{e_{atm}} = 2230\,\frac{m}{s}}$$

b) IN SPACE $\frac{p_e}{p_c} \to 0$

$$\boxed{c_{e_{space}} = 3000\,\frac{m}{s}}$$

$$c_p T_e + \frac{c_e^2}{2} = c_p T_{Tc}$$

$$1500(T_e) + \frac{2230^2}{2} = 1500(3000)$$

$$\boxed{T_{e_{atm}} = 1342\,K} \qquad a = \sqrt{\gamma R T_{e_{atm}}} = 634.5\,m/s$$

$$\boxed{M_{atm} = \frac{c_e}{a} = 3.5}$$

b) IN SPACE

$$\boxed{\begin{array}{l} c_e = 3000\,m/s \\ T_e \to 0, \quad M_e \to \infty \end{array}}$$

c) $\dot{q}^{0} - \dot{w}_s^{0} = h_{T_e} - h_{T_c}$

IF h_{T_c} REDUCED 20% THEN h_{T_e} REDUCED 20%

$\therefore \quad (C_p T_{T_c})(0.8) = C_p T_e + \frac{C_e^2}{2}$

$$\therefore \quad C_e = \sqrt{2 C_p T_{T_c} (0.8) \left[1 - \left(\frac{p_e}{p_c}\right)^{\gamma - 1/\gamma}\right]}$$

$$C_{e_{atm}} = \sqrt{2(1500)(3000)(0.8)\left[1 - \left(\frac{1}{125}\right)^{\frac{1.2-1}{1.2}}\right]}$$

$$\boxed{C_{e\,atm} = 1995 \text{ m/s}}$$

$C_{e\,space} \Rightarrow p_e/p_c \to 0$

$$C_{e\,space} = \sqrt{2(1500)(3000)(0.8)[1]}$$

$$\boxed{C_{e\,space} = 2683 \text{ m/s}}$$