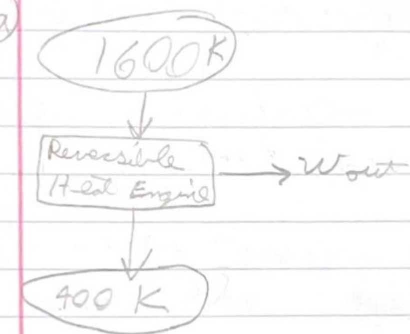
2#10 - Joseph Spectt

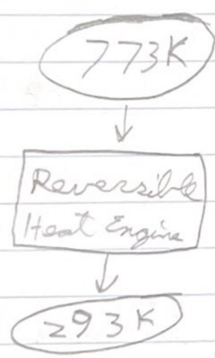
1a)



$\eta_{th} = 1 - \frac{T_c}{T_h} = 1 - \frac{400K}{1600K} = 1 - .25 = .75 = 75\%$

$\boxed{\eta_{th} = .75 = 75\%}$

b)



$\eta_{th} = 1 - \frac{T_c}{T_h} = \frac{W_{net}}{Q_H}$ $\therefore Q_h = \frac{W_{net}}{1 - \frac{T_c}{T_h}}$

$\boxed{Q_h = 1610.42 \text{ kJ}}$

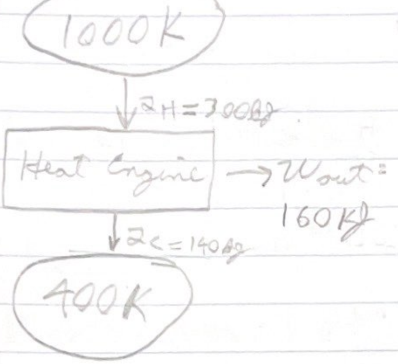
We also know $\eta_{th} = 1 - \frac{T_c}{T_h} = 1 - \frac{Q_c}{Q_h}$

$\therefore \frac{T_c}{T_h} = \frac{Q_c}{Q_h} \Rightarrow Q_c = Q_h\left(\frac{T_c}{T_h}\right) = 1610.42 \text{ kJ} \left(\frac{293K}{773K}\right) = 610.4179$

$\boxed{Q_c = 610.42 \text{ kJ}}$

2 #10 - Joseph Specht

2a)



1st law:

$W_{net} = Q_H - Q_C = (300-140) kJ = 160 kJ$

W_{net} is what it should be!

Also, $\eta_{th} = \frac{W_{net}}{Q_H} = \frac{160 kJ}{300 kJ} = .533 = 53.3\%$

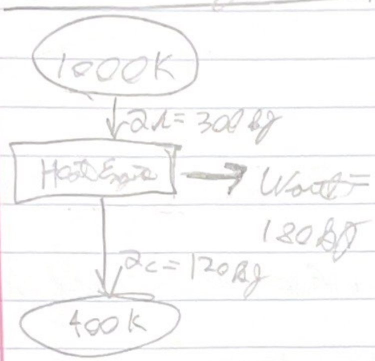
We then need to compare this efficiency to that of a theoretical engine w/ no irreversibilities

2nd law: $\eta_{th} = 1 - \frac{T_C}{T_H} = 1 - \frac{400K}{1000K} = 1 - .4 = .6 = 60\%$

Since the practical efficiency < the theoretical efficiency, this system works & does not need irreversibilities to work!

2#10 - Joseph Specht

2a)



1st law:

$W_{net} = Q_H - Q_C = (300-120)\,kJ = 180\,kJ$

Work matches!

$\eta_{th} = 1 - \frac{Q_C}{Q_H} = 1 - \frac{120\,kJ}{300\,kJ} = 1 - .4 = .6 = 60\%$

2nd law:

$\eta'_{th} = 1 - \frac{T_C}{T_H} = 1 - \frac{400K}{1000K} = 1 - .4 = .6 = 60\%$

$\eta_{th} = \eta'_{th}$ ∴ the process is theoretically possible, but the requirement is no irreversibilities can be present.

Q #10 - Joseph Specht

2c)

$1000\,K$

$\downarrow Q_H = 300\text{ kJ}$

Heat Engine $\rightarrow$ $W_{out} = 170\text{ kJ}$

$\downarrow Q_C = 140\text{ kJ}$

$400\,K$

1st law:

$W_{net} = Q_H - Q_C = 160\text{ kJ}$

$W_{net} < W_{out}$ $\boxed{\therefore \text{NOT POSSIBLE!}}$

Fails first ~~law~~, so this process is impossible.

2d)

$1000\,K$

$\downarrow Q_H = 300\text{ kJ}$

Heat Engine $\longrightarrow$ $W_{out} = 200\text{ kJ}$

$\downarrow Q_C = 100\text{ kJ}$

$400\,K$

1st law:

$W_{net} = Q_H - Q_C = (300-200)\text{ kJ} = 100\text{ kJ}$

$W_{net} = W_{out}$, so checks out!

$\eta_{th} = \frac{W_{out}}{Q_H} = \frac{200\text{ kJ}}{300\text{ kJ}} = .667 = 66.7\%$

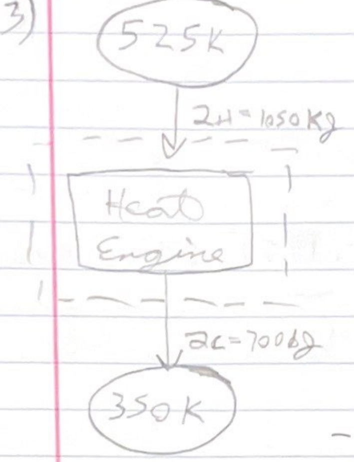
2nd law:

$\eta'_{th} = 1 - \frac{T_C}{T_H} = 1 - \frac{400K}{1000K} = 1 - .4 = .6 = 60\%$

$\eta_{th} > \eta'_{th}$ $\boxed{\therefore \text{ This process is impossible as the cycle efficiency is greater than the theoretical efficiency}}$

2#10 - Joseph Specht

3)



Using Clausius Equality

$$\oint\left(\frac{\delta Q}{T}\right) \le 0$$

which can be written

$$\oint\left(\frac{\delta Q}{T}\right) = -\sigma_{cycle}$$

$$-\sigma_{cycle} = \frac{Q_H}{T_H} - \frac{Q_C}{T_C}$$

$$\Rightarrow -\sigma_{cycle} = \frac{1050\,kJ}{525\,K} - \frac{700\,kJ}{350\,K} = \frac{1}{2K} - \frac{1}{2K} = 0$$

$$\boxed{\sigma_{cycle} = 0}$$

There are no irreversibilities in the cycle meaning it is reversible & almost not possible.