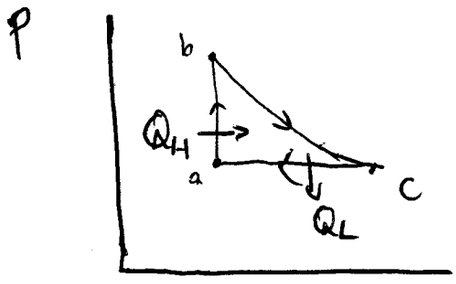
Thermodynamics Problem



$a \to b$ isochoric (same volume)

$b \to c$ adiabatic ($Q = 0$)

$c \to a$ isobaric (same pressure)

Q_H is heat in.

Q_L is heat out.

Given: $n = 1$ moles

monatomic $V_a = 1 \times 10^{-3}\ m^3$

$V_c = 8 V_a$

$P_b = 1.013 \times 10^6\ Pa$ ← 1 atm

~~$P_b = 3.167 \times 10^{-4}\ P_a$~~

a) What is Q_H?

(1) $Q_H = n C_v \Delta T$ ← heat temp. eqn

(2) $\Delta T = \frac{1}{nr}(P_b V_b - P_a V_a)$ ← ideal gas law

(3) $V_a = V_b$ ← from diagram

Combine!

$$Q_H = \frac{3}{2}(P_b - P_a) V_b$$ ← Plug in #s

$$= 1.47 \times 10^3\ J$$

Note:

You find P_a through $P_c V_c^{\gamma} = P_b V_b^{\gamma}$ Please see next page.

(b) Q What is Q_L?

$$\Delta T = \frac{P_b V_b}{nR} - \frac{P_c V_c}{nR}$$

(1) $Q_L = n C_p \Delta T$ ←

(2) $P_b V_b^{\gamma} = P_c V_c^{\gamma}$ (relationship for adiabatic)
$\gamma = 5/3$ (monatomic),
$C_p = \frac{5}{2} R$

(3) $V_a = V_c$ (from graph)

Combine!

$$Q_L = \frac{5}{2} R P_a (V_a - V_c)$$

← Plug in!

$$= -5.54 \times 10^2 \text{ J}$$

$$|Q_L| = \underline{5.54 \times 10^2 \text{ J}}$$

ASIDE: Finding P_a, P_c. Note $P_a = P_c$.

$$P_c = P_b \left(\frac{V_b}{V_c}\right)^{\gamma}$$

$$= 1.013 \times 10^6 \left(\frac{V_b}{5V_b}\right)^{5/3}$$

$$= 3.167 \times 10^4 \text{ Pa}$$

c) Q What is W? (work done)

$W = Q$ since $\Delta E_{int} = 0$ for complete cycle. (1st law)

$= Q_H - Q_L$

Plug in → $= \underline{9.18 \times 10^2 \text{ J}}$

d) Q What is efficiency?

$$e = \frac{W}{Q_H} = 0.624 \text{ or } \underline{62.4\%}$$