1/

Physics 9B Fall 2013

Assignment 6

ch 20 - 3, 5, 7, 11, 19, 37, 41, 43, 46, 51

12 - 3, 14, 21, 23, 27, 37, 41, 43, 63, 71

20-3

$\underset{16100}{Q_H} + Q_c = \underset{3700}{W}$

(b) $Q_c = \underset{\text{out}}{-12400}$

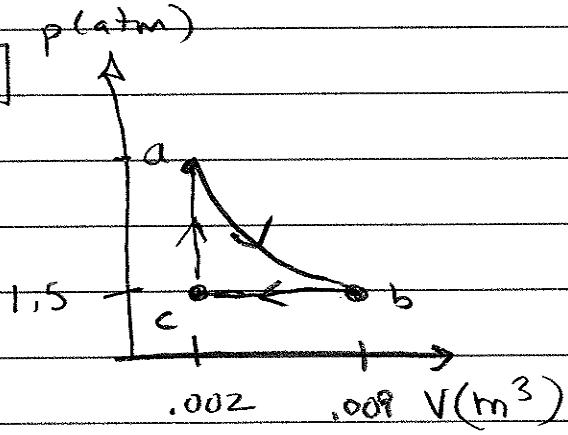
(a) $e = 3700/16100 = .23$

(c) $m = 16100/46000 = 0.35\,g$

(d) $(3700)(60) = 222000\ W = 298\ Hp$

746 W = 1 HP

20-5



$n = 0.25$ moles ideal gas

$\gamma = 1.4$

(a)

ab = adiabatic $P_b V_b^\gamma = P_a V_a^\gamma \Rightarrow P_a = P_b \left(\frac{V_b}{V_a}\right)^\gamma = 12.31$ atm

Can get $T_c = \frac{P_c V_c}{nR} = 146$ $T_b = 656$ $T_a = 1799$

$\frac{5}{2}R$

20-5 cont'd $\Delta U_{ab} = nC_V(T_b - T_a) = -2821$

$\Delta U_{bc} = nC_V(T_c - T_b) = -2650$

$\Delta U = Q - W$ $\Delta U_{ca} = nC_V(T_a - T_c) = +5471$

$W_{ab} = -\Delta U_{ab} = +2821$ J since $Q_{ab} = 0$ (adiabatic)

$W_{bc} = P\Delta V = -1061$ J so $Q_{bc} = \Delta U_{bc} + W_{bc} = -3710$

$W_{ca} = \phi$ so $Q_{ca} = \Delta U_{ca} = +5471$

$W_{TOT} = 1760$ J so $e = \frac{1760}{5471} = .32$

Check another method: $Q = nC_p\Delta T$

$e_{carnot} = 1 - \frac{146}{1199} = .88$

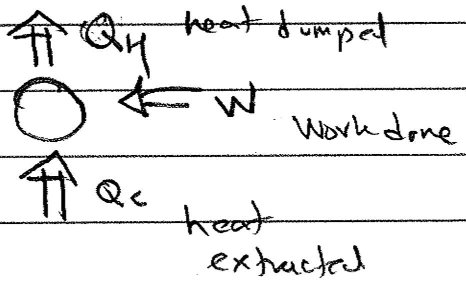
$\boxed{20-7}$ $r = 8.8$ $\gamma = 1.4$; $r = 9.6$

a) $e = 1 - 1/r^{\gamma - 1}$ (for otto) $= 0.581$

additional 1.4%

b) $= 0.595$

$\boxed{20-11}$ $K = |Q_c| / |Q_H| - |Q_c|$ "coeff. of performance"



$W = 95$ $K = 2.25$

$m = 12000$ g H_2O
$C = 4190$ J/kg
$\Delta T = 26°$

$Q_c = 1.31 \cdot 10^6$ J

$K = \dfrac{|Q_c|}{|W|}$

$Q_c = k|W| = 2.2$

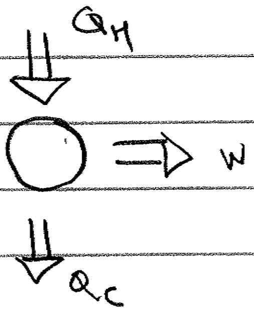
can cool $(2.25)(95) = 218$ W

$1.31 \cdot 10^6 /$ $= 6457$ sec $(\sim 108$ min$)$

$\boxed{20\ 19}$ Carnot $e = 0.60$

$T_H = 800$

$Q_C = 3000\ J$



$$e = 1 - \left|\frac{Q_C}{Q_H}\right| = .6$$

$$\left|\frac{Q_C}{Q_H}\right| = .4 \qquad Q_H = \frac{3000}{.4} = 7500 J$$

$$W = 4500\ J$$

$\boxed{20-37}$ $T_H = 135^\circ C$ $Q_H = 150\ J$

$e = .22$

a) $.22 = 1 - \left|\frac{Q_C}{Q_H}\right|$ $\left|\frac{Q_C}{Q_H}\right| = .78$ (b) $Q_C = 117\ J$

(a) $W = 33\ J$

(c) $e = 1 - T_C/T_H$ $T_C/T_H = .78$

$$T_C = (.78)(\overbrace{135+273}^{408}) = 318$$

(d) $\Delta S = \frac{-|Q_H|}{T_H} + \frac{|Q_C|}{T_C} = \frac{-150}{408} + \frac{117}{318} = 0$

Carnot is reversible $\Delta S = 0$

(e) $mgh = E$ $m = \frac{33}{(9.8)(35)} = .096\ kg$

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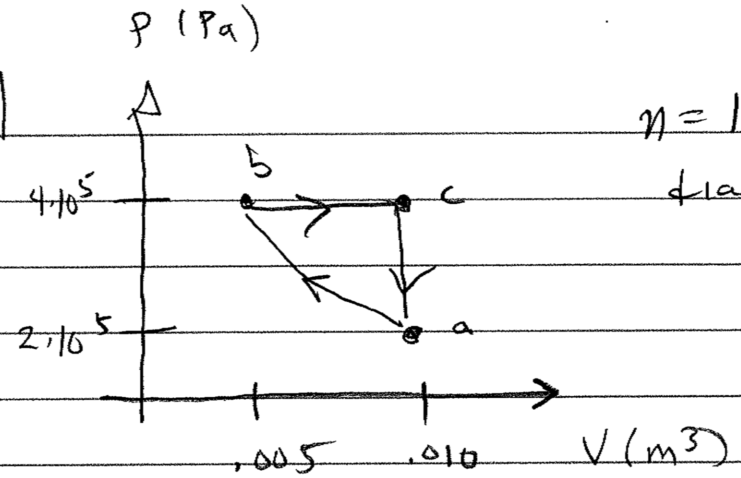
$\boxed{20-41}$



$n = 1$ mole
diatomic gas

a) $T_a = P_aV_a/nR = 241$

$T_b = P_bV_b/nR = 241$

$T_c = P_cV_c/nR = 482$

$\Big\}\ P_aV_a = P_bV_b$

b) $\Delta U = Q - W$

on bc gas does work and yet T rises, Q must be absorbed.

on ca gas does no work and T falls ⇒ Q must flow out.

on ab, $\Delta U = 0$ but $W < 0$ so $Q < 0$ ⇒ Q flows out

d) $W_{bc} = P\Delta V = +2000\text{ J}$

$W_{ca} = 0$

$W_{ab} = nRT\ln\frac{V_b}{V_a} = -1389\text{ J}$

$W_{net} = 611\text{ J}$

$\Delta U_{bc} = nC_v\Delta T = 5009$

$Q_{bc} = 7009$

$\Delta U_{ca} = nC_v\Delta T = -5009$

$Q_{ca} = -5009$

$\Delta U_{ab} = 0$

$Q_{ab} = -1389$

$e = 611/7009 = 8.7\%$

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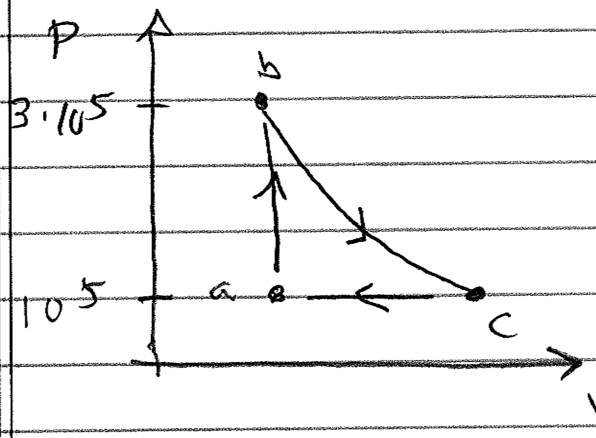
$\boxed{20-43}$ $n = 2$ moles He (monatomic)

$T_{max} = 327$ C $= T_b = T_c = 600$ °K

bc = isothermal



$V_a = V_b = \frac{nRT_b}{P_b} = .0333 \ m^3$

$V_c = \frac{nRT_c}{P_c} = .1 \ m^3$

$T_a = \frac{P_a V_a}{nR} = 200$ K

$\Delta U = Q - W$

$\Delta U_{ab} = Q_{ab} - \cancel{W_{ab}} \rightarrow 0$

$nC_v \Delta T = 2(\frac{3}{2}R)(400)$ $Q_{ab} = 9977$ J

$\Delta U_{bc} = 0 = Q_{bc} - W_{bc}$

$nRT \ln \frac{V_c}{V_b} = 10961 \text{ J} = W_{bc} = Q_{bc}$

$Q_{in} = Q_{ab} + Q_{bc} = 20938$ J

$\Delta U_{ca} = -9977$ J $\Rightarrow Q_{ca} = 16647$

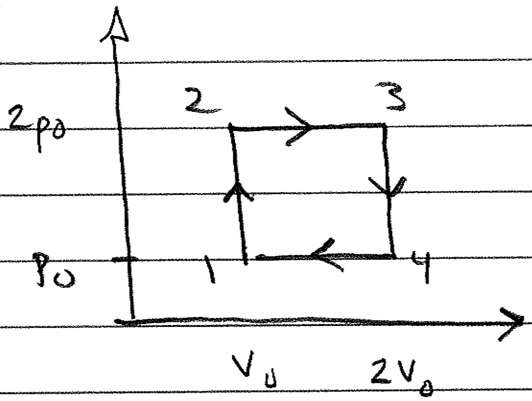
$W_{ca} = P\Delta V = -6670$

$W_{TOT} = 4291$ $e = W/Q_{in} = .205$

$e_{max} = 1 - T_c/T_H = 1 - 200/600 = .67$

7/1

$\boxed{20-46}$



n moles diatomic ideal gas

$1 \to 2$ $\quad W_{12} = 0 \quad Q_{12} = \Delta U_{12} = nC_v(T_2 - T_1)$

$$\left.\begin{array}{l} P_1V_1 = nRT_1 \\ P_2V_2 = nRT_2 \end{array}\right\} \quad T_2 - T_1 = \frac{V_1(P_2 - P_1)}{nR} = \frac{(2p_0 - p_0)V_0}{nR}$$

$V_1 = V_2$

$Q_{12} = nC_v\, V_0p_0/nR = p_0V_0C_v/R$ (heat absorbed)

$2 \to 3$ $\quad W_{23} = P\Delta V = 2p_0V_0$

$\Delta P = 0 \Rightarrow Q_{23} = nC_p\Delta T = nC_p(T_3 - T_2) = nC_p\frac{2p_0V_0}{nR}$

$$\left.\begin{array}{l} P_2V_2 = nRT_2 \\ P_3V_3 = nRT_3 \end{array}\right\} \quad 2p_0V_0 = nR(T_3 - T_2)$$

same $2p_0$

$Q_{23} = 2p_0V_0C_p/R$

20-46 cont'd

$3 \rightarrow 4 \quad \Delta V = 0 \quad W_{34} = 0$

$$Q = n C_V \underset{\substack{\uparrow \\ \frac{V \Delta P}{nR}}}{\Delta T} = n C_V \frac{2V_0(-p_0)}{nR} = \frac{-2p_0 V_0 C_V}{R}$$

$4 \rightarrow 1 \quad \Delta P = 0 \quad W_{41} = P \Delta V = -P_0 V_0$

$$Q = n C_p \Delta T = n C_p \frac{P_0(-V_0)}{nR} = -P_0 V_0 C_p / R$$

$$W_{TOT} = 2p_0V_0 - p_0V_0 = p_0 V_0$$

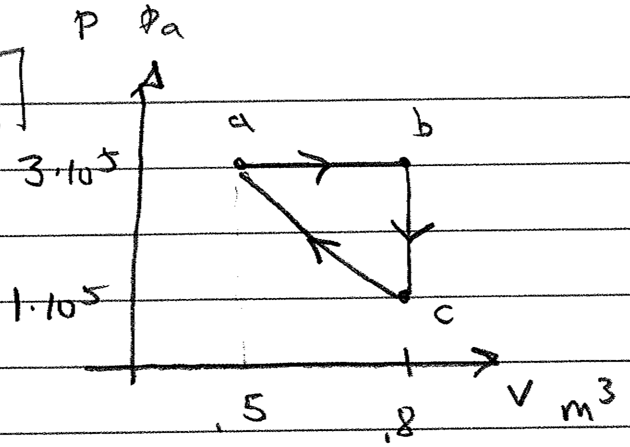
$$Q_{in} = p_0 V_0 \frac{C_V}{R} + 2p_0 V_0 \frac{C_p}{R} = p_0 V_0 \left\{ \frac{5}{2} + \frac{14}{2} \right\} = p_0 V_0 \, {}^{19}\!/_{2}$$

$$\left. \begin{array}{l} C_V = \frac{5}{2} R \\ C_p = \frac{7}{2} R \end{array} \right\} \text{diatomic}$$

$$e = W_{tot} / Q_{in} = 2/19$$

9

20-51



ca is straight line

monatomic

n moles

set n = 1

$C_V = \frac{3}{2}R$

$T_a = P_aV_a/nR = (3\cdot10^5)(.5)/8.314\,n = 18042/n$

$T_b = P_bV_b/nR = (3\cdot10^5)(.8)/8.314\,n = 28867/n$

$T_c = P_cV_c/nR = (1\cdot10^5)(.8)/8.314\,n = 9622/n$

$\Delta U_{ab} = nC_V\Delta T = n\frac{3}{2}R\,\frac{(2.4-1.5)\cdot10^5}{nR} = 1.35\cdot10^5\text{ J}$

$\Delta U_{bc} = n\frac{3}{2}R\,\frac{(.8-2.4)\cdot10^5}{nR} = -2.4\cdot10^5\text{ J}$

$\Delta U_{ca} = n\frac{3}{2}R\,\frac{(1.5-.8)\cdot10^5}{nR} = +1.05\cdot10^5\text{ J}$

$W_{ab} = P\Delta V = (3\cdot10^5)(.3) = 0.9\cdot10^5\text{ J}$

$W_{bc} = 0$

$W_{ca} = -\frac{1}{2}(1+3)\cdot10^5(.3) = -0.6\cdot10^5\text{ J}$

$\Delta U = Q - W$

$Q = \Delta U + W$

$Q_{ab} = 2.25\cdot10^5$

$Q_{bc} = -2.4\cdot10^5$

$Q_{ca} = -.45\cdot10^5$

$e = \frac{W}{Q_{in}} = \frac{.3\cdot10^5}{2.25\cdot10^5}$

$= .133$