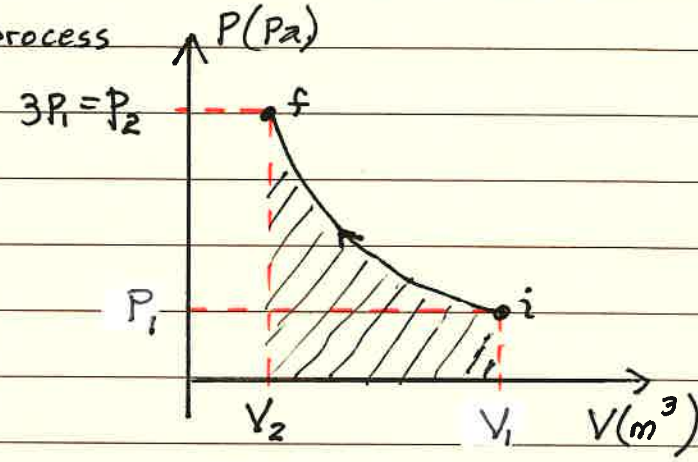
Chapter 19 In-Class Solutions

Ex. 3 Two moles of an ideal gas are compressed in a cylinder at a constant temperature of 65°C until ....

a.) Sketch a p-V diagram for this process



b.) Calculate the amount of work done.

$$\text{Work}_{\text{by the gas}} = nRT \ln\left(\frac{V_2}{V_1}\right)$$

$$\text{Work}_{\text{on the gas}} = nRT \ln\left(\frac{V_1}{V_2}\right)$$

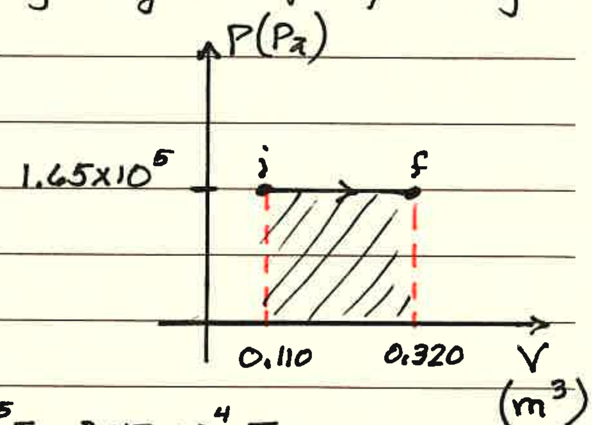
$P_1 V_1 = P_2 V_2 = nRT$ ← a constant

$$= 2\,\text{mol.}\,(8.31\ \text{J/mol}\cdot\text{K})(65+273)\ \ln\left(\frac{P_2 = 3P_1}{P_1}\right)$$

$\ln(3)$

$$\boxed{\text{Work}_{\text{on the gas}} = 6{,}172\ \text{J}}\qquad 6.17\times10^{3}\ \text{J}$$

Ex. 9 A gas in a cylinder expands from a volume of $0.110\ m^3$ to $0.320\ m^3$. Heat flows into the gas just rapidly enough...
Pressure = constant.



a.) $W = p\,\Delta V$

$= 1.65\times10^5\,(0.320 - 0.110)\ \text{Pa}\cdot m^3$

$\boxed{W = 34{,}650\ \text{J}}$ $\quad 3.47\times10^4\ \text{J}$

b.) $Q = \Delta U + W \qquad \Delta U = Q - W = 1.15\times10^5\ \text{J} - 3.47\times10^4\ \text{J}$

$\boxed{\Delta U = 80{,}350\ \text{J}}$ $\quad 8.04\times10^4\ \text{J}$

c.) It does not matter whether or not if this is an ideal gas. ← Did not use $pV = nRT$

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Ex. 13 The pV diagram shown in Fig. E19.13 shows a process abc involving 0.450 moles of an ideal gas.

a.) $T_a = ?$ $T_b = ?$ $T_c = ?$ $T = \frac{pV}{nR}$ $\frac{1}{nR} = 0.2674 \text{ K/J}$

$$T_a = \frac{P_a V_a}{nR} = (2.0\times10^5 \text{ Pa})(0.010 \text{ m}^3)(0.2674 \text{ K/J}) = \underline{\underline{535 \text{ K}}}$$

$$T_b = \frac{P_b V_b}{nR} = (5.0\times10^5 \text{ Pa})(0.070 \text{ m}^3)(0.2674 \text{ K/J}) = \underline{\underline{9{,}360 \text{ K}}}$$

$$T_c = \frac{P_c V_c}{nR} = (8.0\times10^5 \text{ Pa})(0.070 \text{ m}^3)(0.2674 \text{ K/J}) = \underline{\underline{14{,}975 \text{ K}}}$$

b.) How much work was done "on" or "by" the gas in this process? $W_{a\to b\to c} = ?$

$W_{a\to b}$ = area of a trapezoid $= \frac{1}{2}(5.0+2.0)\times10^5 \text{ Pa}\,(7-1)\text{ m}^3\times10^{-2}$

$W_{a\to b} = 21{,}000 \text{ J}$ "by" gas

$W_{b\to c} = 0 \text{ J}$, because there is no change in volume.

$\boxed{W_{a\to b\to c} = 21{,}000 \text{ J}}$ "by" the gas.

c.) How much heat (Q) had to be added such that $\Delta U = 15{,}000 \text{ J}$

$Q = \Delta U + W = 15{,}000 \text{ J} + 21{,}000 \text{ J}$ $\boxed{Q = 36{,}000 \text{ J}}$

Ex. 19 In an experiment to simulate conditions within an automobile engine, ...

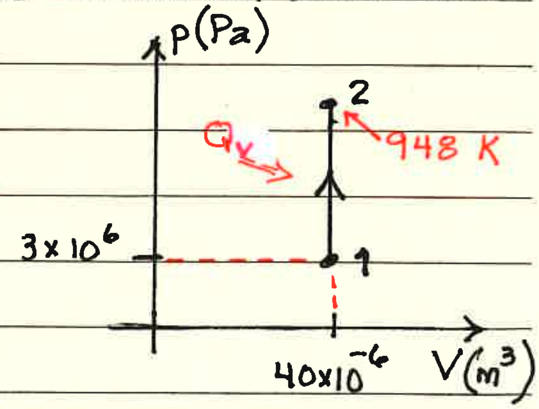
$n = 0.185$ mol of air

$T_1 = 780 \text{ K}$ $P_1 = 3.00\times10^6 \text{ Pa}$

$Q = 645 \text{ J}$ $T_2 = ?$

$Q = \Delta U + W$ ← $=0$ $Q = \Delta U = nC_V\,\Delta T$

$\Delta T = Q/(nC_V)$



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Chapter 19 In-Class Problems

Ex. 19 cont'd

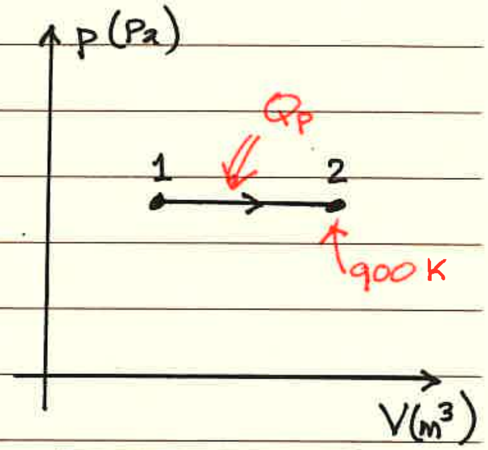
$$\Delta T = \frac{645\ J}{(0.185\ mol)(20.76\ J/mol \cdot K)}$$

$\Delta T = 168\ K$

$T_2 = T_1 + \Delta T$ (780 K, 168 K)

const. volume → $\boxed{T_2 = 948\ K}$

b.) The cylinder's volume is allowed to increase while the pressure → constant.



$Q_p = n C_p \Delta T$

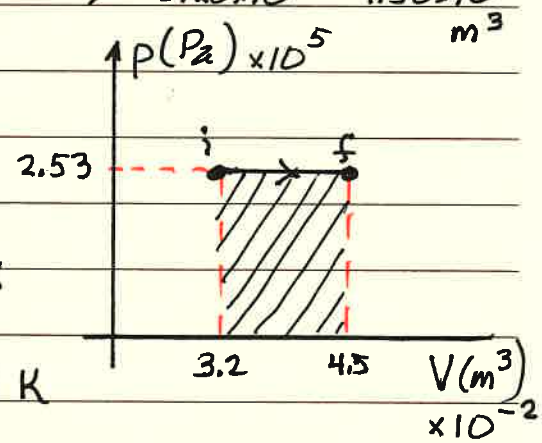
$645\ J = (0.185\ mol)(29.07\ J/mol \cdot K)\,\Delta T$

$$\Delta T = \frac{645\ J}{(0.185\ mol)(29.07\ J/mol \cdot K)}$$

$\Delta T = 120\ K$

$T_2 = T_1 + \Delta T = 780\ K + 120\ K$ $\boxed{T_2 = 900\ K}$

Ex. 22 Three moles of an ideal monatomic gas expands at constant pressure → 2.50 atm. $\Delta V \Rightarrow 3.20 \times 10^{-2} \rightarrow 4.50 \times 10^{-2}\ m^3$



$p = 2.50\ atm\ (1.013 \times 10^5\ Pa/atm)$

$p = 2.53 \times 10^5\ Pa$

a.) $T_i = \frac{p_i V_i}{nR} = \frac{(2.53 \times 10^5)(3.2 \times 10^{-2})}{(3\ mol)(8.31)} = 325\ K$

$T_f = \frac{p_f V_f}{nR} = \frac{(2.53 \times 10^5)(4.5 \times 10^{-2})}{(3\ mol)(8.31)} = 457\ K$

b.) $W = ?$ $W = p\,\Delta V = (2.53 \times 10^5\ Pa)(4.5 - 3.2) \times 10^{-2}\ m^3$

$\boxed{W = 3289\ J}$

c.) $Q = ?$ $Q_p = n C_p \Delta T = (3\ mol)\left(\frac{5}{2}\ 8.31\ J/mol \cdot K\right)(457 - 325)\ K$

$\boxed{Q_p = 8{,}227\ J}$ book's answer → $8.17 \times 10^3\ J$

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Chapter 19 In-Class Solutions

Ex. 22 cont'd

d.) $\Delta U = ?$ $Q = \Delta U + W$ $\Delta U = Q - W = 8227\,J - 3289\,J$

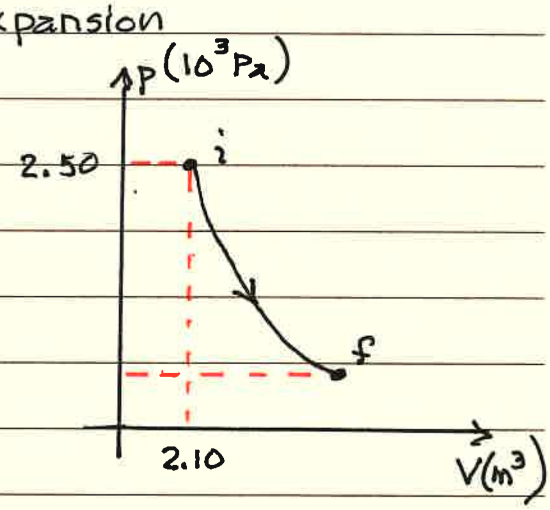
$\boxed{\Delta U = 4938\,J}$ Book's answer → $4.88 \times 10^3\,J$

The source of the difference between the book's answers and my answers is due to final temperature ($T_f = 457\,K$). The book uses 456 K. The calculated temperature is actually 456.68 K. They "rounded down" and I "rounded up."

Ex. 28 Five moles of an ideal monatomic gas have an initial pressure of 2.50×10^3 Pa and an initial volume of $2.10\,m^3$

$W = 1480\,J$ after an adiabatic expansion

$P_f = ?$



① $p_1 V_1^{\gamma} = p_2 V_2^{\gamma}$

② $W = \dfrac{1}{\gamma - 1}(p_1 V_1 - p_2 V_2)$

② $p_2 V_2 = p_1 V_1 - (\gamma - 1) W$

① $V_2^{\gamma} = V_1^{\gamma} \dfrac{p_1}{p_2}$ $V_2 = V_1 \left(\dfrac{p_1}{p_2}\right)^{1/\gamma}$

② $p_2 \left(V_1 \left(\dfrac{p_1^{1/\gamma}}{p_2^{1/\gamma}} \right) \right) = p_1 V_1 - (\gamma - 1) W \Rightarrow p_2^{1 - 1/\gamma} = \dfrac{p_1 V_1 - (\gamma - 1) W}{p_1^{1/\gamma} V_1}$

$\left(\gamma = \frac{5}{3}\right) \Rightarrow p_2^{2/5} = \dfrac{p_1 V_1 - (\gamma - 1) W}{p_1^{1/\gamma} V_1}$ $p_2 = \left(\dfrac{p_1 V_1 - \frac{2}{3} W}{p_1^{3/5} V_1} \right)^{5/2}$

$p_2 = \left(\dfrac{(2.5 \times 10^3)(2.10) - \frac{2}{3}(1480)}{(2.5 \times 10^3)^{3/5}(2.10)} \right)^{5/2} = \boxed{1486\,Pa}$