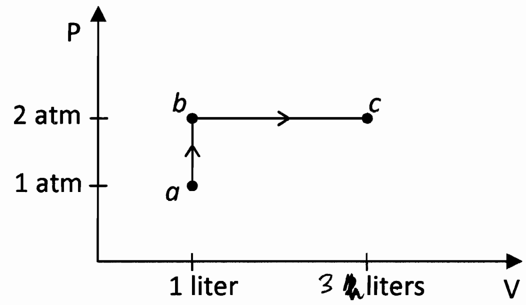
SOLUTIONS

Thermodynamics Worksheet #1:

An ideal gas in a rectangular cycle



A sample of N_2 gas starts out at pressure $P_a = 10^5$ N/m^2 (about 1 atm), volume $V_a = 1$ liter, temperature $T_a = 300$ K.

1. Find the number of moles n of the gas.

$$n = \frac{P_a V_a}{R T_a} = 0.0401 \text{ moles}$$

(useful fact for later: $nR = \frac{1}{3}$ J/K)

2. The gas is heated at constant volume from point a to point b, then heated a constant pressure to point c. Find the temperatures T_b and T_c.

$a \to b$: V constant.

$$\frac{nRT_a}{P_a} = \frac{nRT_b}{P_b}$$

$$T_b = \left(\frac{P_b}{P_a}\right) T_a = 600K$$

$b \to c$ P constant

$$\frac{nRT_b}{V_b} = \frac{nRT_c}{V_c}$$

$$T_c = \left(\frac{V_c}{V_b}\right) T_b = 1800K$$

3. Find the change in the internal energy E for the gas for the processes $a \to b$ and $b \to c$. (Call these ΔE_{ab} and ΔE_{bc}.)

$$E = \frac{5}{2} nRT$$

$$\Delta E_{ab} = \frac{5}{2} nR \Delta T_{ab}$$

$$\Delta E_{ab} = 250 J$$

$$\Delta E_{bc} = \frac{5}{2} nR \Delta T_{bc}$$

$$\Delta E_{bc} = 1000 J$$

4. Find the work done on the gas for each process, W_{ab} and W_{bc}.

$W = -\int P dV$

$W_{ab} = 0.$

$W_{bc} = -P_b \Delta V = (2\times10^{5}\,Pa)(2\times10^{-3}\,m^3)$

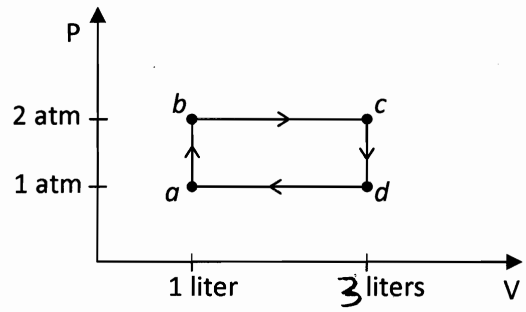
$W_{bc} = -400J$

5. Find the heat added to the gas, Q_{ab} and Q_{bc}.

$Q_{ab} = \Delta E_{ab} - W_{ab} = 250\ J$

$Q_{bc} = \Delta E_{bc} - W_{bc} = 1400J$

Now the gas is cooled at constant volume from point c to point d, and cooled at constant pressure from point d back to point a.



6. Find the temperature T_d at point d.

$T_d = \left(\frac{V_d}{V_c}\right) T_c = 900k$

7. Complete the following table.

	ΔE	W	Q
$a \rightarrow b$	+250 J	0	+250 J
$b \rightarrow c$	+1000J	−400 J	+1400 J
$c \rightarrow d$	−750J	0	−750J
$d \rightarrow a$	−500 J	+200J	−700J
NET:	0	−200J	+200J