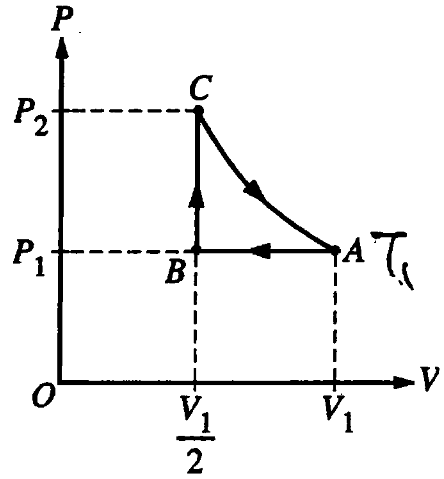
AP® Physics B
2004 Sample Student Responses
Form B

A1



5. (10 points)

One mole of an ideal gas is initially at pressure P_1, volume V_1, and temperature T_1, represented by point A on the PV diagram above. The gas is taken around cycle $ABCA$ shown. Process AB is isobaric, process BC is isochoric, and process CA is isothermal.

(a) Calculate the temperature T_2 at the end of process AB in terms of temperature T_1.

$$\frac{P_1 V_1}{T_1} = \frac{P_1 \times \frac{V_1}{2}}{T_2} \Rightarrow T_2 = T_1 \times \frac{V_1}{2} \times \frac{1}{V_1} = \frac{T_1}{2}$$

(b) Calculate the pressure P_2 at the end of process BC in terms of pressure P_1.

$$\frac{P_1 \times \frac{V_1}{2}}{T_2} = \frac{P_2 \times \frac{V_1}{2}}{T_1} \qquad \frac{2P_1}{T_1} = \frac{P_2}{T_1} \Rightarrow P_2 = 2P_1$$

for $T_2 = \frac{T_1}{2}$

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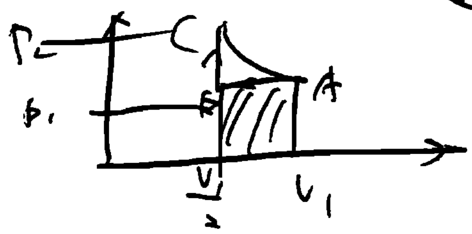
A2

(c) Calculate the net work done on the gas when it is taken from A to B to C. Express your answer in terms of P_1 and V_1.

The work done on the gas is ~~the~~ area under the A→B→C which was



the shaded region is the work done on gas by surrounding.

$\therefore W = (V_1 - \frac{V_1}{2}) \times P_1$

$= \frac{V_1 P_1}{2}$

(d) Indicate below all of the processes that result in heat being added to the gas.

____ AB __✓__ BC __✓__ CA

Justify your answer.

$Q = \Delta U - W$

when $\Delta U = \frac{3}{2} nR\Delta T$

$W = -P\Delta V$

i) in process A→B

$\Delta U = \frac{3}{2} 1 \times 8.31 \times (T_2 - T_1)$

$= \frac{3}{2} \times 8.31 \times (-\frac{T_1}{2})$

$= -6.23\ T_1$

$W = -P_1 \times (\frac{V_1}{2} - V_1)$

$= -P_1(-\frac{V_1}{2})$

$= \frac{P_1 V_1}{2}$

$Q = -6.23T_1 - \frac{P_1V_1}{2} < 0$

ii) in process B→C

$W = 0$ for $\Delta V = 0$

$\Delta U = \frac{3}{2} nR\Delta T$

$\Delta T = T_1 - \frac{T_1}{2}$

$= \frac{T_1}{2}$

$\therefore \Delta U = \frac{3}{2} \times 8.32 \times \frac{T_1}{2}$

$Q = \Delta U > 0$

iii) in process C→A

$Q = \Delta U - W$

$\Delta U = \frac{3}{2} nR\Delta T$ $\Delta T = 0$

$\therefore \Delta U = 0$

$W =$ (the area under the graph)

$Q = -W > 0$

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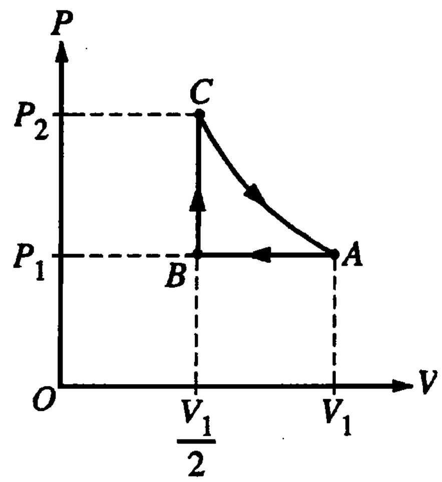
B1



5. (10 points)

One mole of an ideal gas is initially at pressure P_1, volume V_1, and temperature T_1, represented by point A on the PV diagram above. The gas is taken around cycle $ABCA$ shown. Process AB is isobaric, process BC is isochoric, and process CA is isothermal.

(a) Calculate the temperature T_2 at the end of process AB in terms of temperature T_1.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \qquad V_2 = \frac{V_1}{2} \qquad \frac{V_1/2}{T_2}$$

$$\frac{V_1}{T_1} = \frac{V_1}{2T_2} = T_1 = 2T_2$$

$$T_2 = \frac{T_1}{2}$$

(b) Calculate the pressure P_2 at the end of process BC in terms of pressure P_1.

$$\frac{P_2}{T_2} = \frac{P_1}{T_1}$$

$$P_2 = \frac{P_1}{T_1} \times T_2 \qquad \boxed{T_1 = 2T_2}$$

$$= \frac{P_1}{2T_2} \times T_2$$

$$P_2 = \frac{P_1}{2}$$

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(c) Calculate the net work done on the gas when it is taken from A to B to C. Express your answer in terms of P_1 and V_1.

$$W = -P\Delta V$$

$$= -\frac{P_1}{2}\left(\frac{V_1}{2} - V_1\right)$$

$$=$$

(d) Indicate below all of the processes that result in heat being added to the gas.

____ *AB*   ✓ *BC*   ✓ *CA*

Justify your answer.

AB: $\Delta U = Q + w$ $PV = nRT$ (↓ ↓)

W is positive and therefore temperature should increase but it decreases.

Q is negative.

BC: $\Delta U = Q + w$ $PV = nRT$ (↑ ↑)

$W = 0$

P increases & temperature increases.

Q is added.

CA: isotherm. $PV = nRT$

Work is negative and so Q has to be positive in order to keep the constant temperature.

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