



AP[®] Physics B
2004 Sample Student Responses
Form B

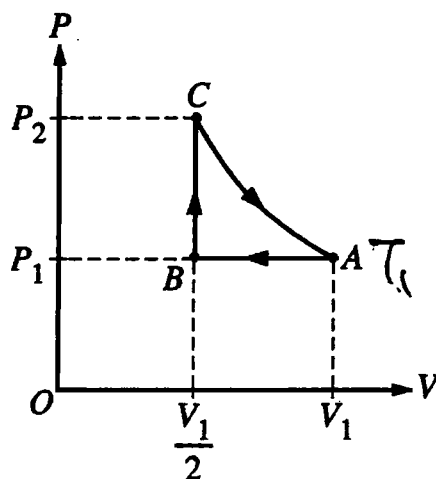
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5. (10 points)

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 .

AT B

~~$$\Delta U = nP\Delta V$$~~

~~$$\Delta T = \frac{P\Delta V}{nR} = \frac{P_1 \left(\frac{V_1}{2} - V_1 \right)}{1 \times (8-3) R} = \frac{P_1 \left(-\frac{V_1}{2} \right)}{5R}$$~~

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

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

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

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

$$\frac{2P_1}{T_2} = \frac{P_2}{T_1}$$

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

$$\therefore P_2 = 2P_1$$

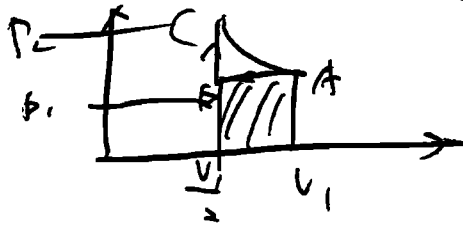
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(c) Calculate the net work done on the gas when it is taken from A to B to C. Express your answer in terms of P_1 and V_1 .

A2

The work done on the gas is the area under

the $A \rightarrow B \rightarrow C$ 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.

$$Q = \Delta U - W$$

$$\text{when } \Delta U = \frac{3}{2} n R \Delta T$$

$$W = -p \Delta V$$

i) in process $A \rightarrow B$

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

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

$$= -6.23 T_1$$

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

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

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

$$Q = -6.23 T_1 - \frac{P_1 V_1}{2} < 0$$

ii) in process $B \rightarrow C$

$$W = 0 \text{ for } \Delta V = 0$$

$$\Delta U = \frac{3}{2} n R \Delta T$$

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

$$\therefore \Delta U = \frac{3}{2} \times 8.31 \times \frac{T_1}{2}$$

$$Q = \Delta U > 0$$

iii) in process $C \rightarrow A$

$$Q = \Delta U - W$$

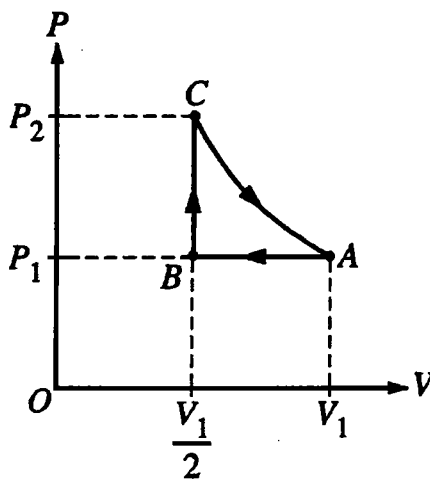
$$\Delta U = \frac{3}{2} n R \Delta T \quad \Delta T = 0$$

$$\therefore \Delta U = 0$$

$W =$ (the area under the graph)

$$Q = -W > 0$$

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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 .

$$\frac{PV_1}{T_1} = \frac{PV_2}{T_2}$$

$V_2 = \frac{V_1}{2}$

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

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

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

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

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

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

$T_1 = 2T_2$

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

GO ON TO THE NEXT PAGE.

- (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 .

$$\begin{aligned}
 W &= -P\Delta V \\
 &= -\frac{P_1}{2} \left(\frac{V_1}{2} - V_1 \right) \\
 &=
 \end{aligned}$$

- (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: isothermal.

$$PV = nRT$$

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

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