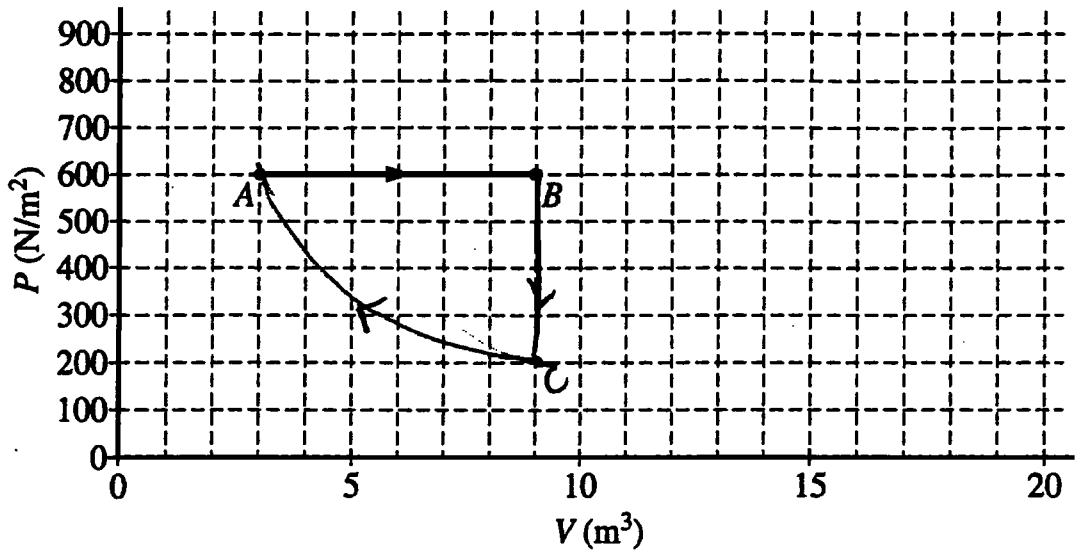
AP® Physics B (Operational)
2004 Sample Student Responses

A1



5. (10 points)

The diagram above of pressure P versus volume V shows the expansion of 2.0 moles of a monatomic ideal gas from state A to state B. As shown in the diagram, $P_A = P_B = 600\ \text{N/m}^2$, $V_A = 3.0\ \text{m}^3$, and $V_B = 9.0\ \text{m}^3$.

(a)

i. Calculate the work done by the gas as it expands.

$W = -P\Delta V$

$= -(600)(9-3)$

$= -3600\ \text{J}$

Gas does 3600J of work

ii. Calculate the change in internal energy of the gas as it expands.

$PV = nRT$

$(3)(600) = (2)(8.31)T \qquad T = 108\ \text{K}$

$(9)(600) = (2)(8.31)T \qquad T = 325\ \text{K}$

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

$\frac{3}{2}(2)(8.31)(325-108)$

$= 5404.81\ \text{J}$

$= 5400\ \text{J}$

iii. Calculate the heat added to or removed from the gas during this expansion.

$\Delta U = Q + W$

$5400 = Q - 3600$

$Q = 9000\ \text{J}$

9000J of heat is added

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A2

(b) The pressure is then reduced to 200 N/m^2 without changing the volume as the gas is taken from state *B* to state *C*. Label state *C* on the diagram and draw a line or curve to represent the process from state *B* to state *C*.

(c) The gas is then compressed isothermally back to state *A*.

i. Draw a line or curve on the diagram to represent this process.

ii. Is heat added to or removed from the gas during this isothermal compression?

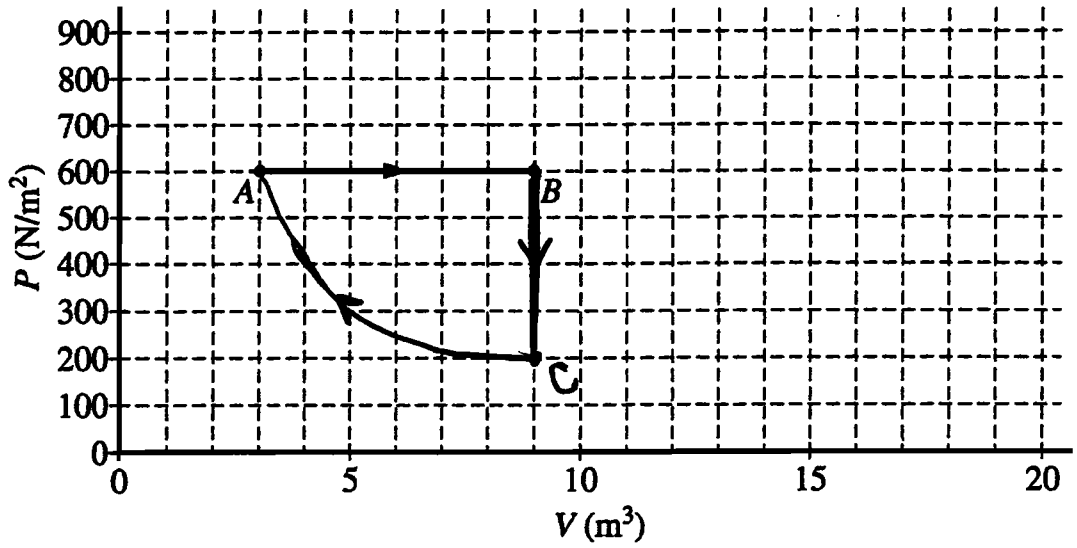
____ added to ✓ removed from

Justify your answer.

$W = -P\Delta V$

Change in volume is negative, which means work is done on the system. Since $\Delta U = 0$ for an isothermal process, heat must be removed from system so $0 = Q + W$

B1



5. (10 points)

The diagram above of pressure P versus volume V shows the expansion of 2.0 moles of a monatomic ideal gas from state A to state B. As shown in the diagram, $P_A = P_B = 600\ \text{N/m}^2$, $V_A = 3.0\ \text{m}^3$, and $V_B = 9.0\ \text{m}^3$.

(a)

i. Calculate the work done <u>by the gas</u> as it expands.

$W = -P\Delta V$

$W = -(600\text{N/m}^2)(9\text{m}^3 - 3\text{m}^3)$

$W = -3600\text{J}$

ii. Calculate the change in internal energy of the gas as it expands.

$\Delta U = Q + W$

$\Delta U = \frac{3}{2}P\Delta V$

$\Delta U = \frac{3}{2}(600\text{N/m}^2)(6\text{m}^3)$

$\Delta U = 5400$

iii. Calculate the heat added to or removed from the gas during this expansion.

$\Delta U = Q + W$

$\Delta U - W = Q$

$5400 - (-3600) = Q$

$9{,}000\text{J} = Q$

GO ON TO THE NEXT PAGE.

B2

(b) The pressure is then reduced to 200 N/m^2 without changing the volume as the gas is taken from state *B* to state *C*. Label state *C* on the diagram and draw a line or curve to represent the process from state *B* to state *C*.

(c) The gas is then compressed isothermally back to state *A*.

i. Draw a line or curve on the diagram to represent this process.

ii. Is heat added to or removed from the gas during this isothermal compression?

____ added to √ removed from

Justify your answer.

$\Delta U = Q + W$

$\Delta U = 0$ because $\Delta U = \frac{3}{2} nR\Delta t$ and there was no change in temp. ↑ Isothermal

Heat was added from $A \rightarrow B$ and therefore must be removed from $C \rightarrow A$ to get back to its original state.