



AP[®] Physics B (Operational) 2004 Sample Student Responses

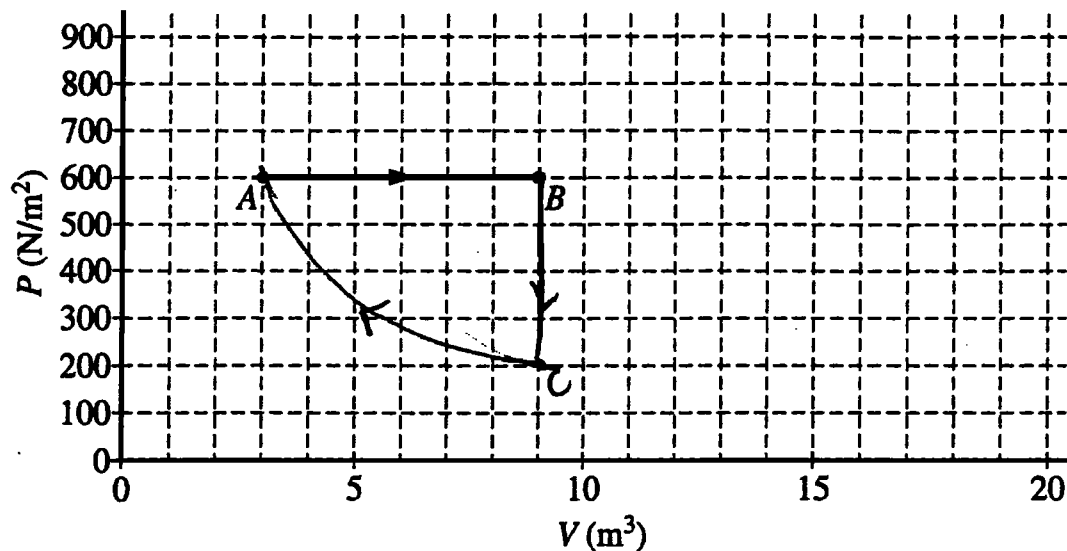
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5. (10 points)

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.

$$\begin{aligned} W &= -P \Delta V \\ &= -(600)(9 - 3) \\ &= -3600 \text{ J} \end{aligned}$$

Gas does 3600 J of work

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

$$PV = nRT$$

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

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

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

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

$$= 5409.81 \text{ J}$$

$$= 5400 \text{ J}$$

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

$$\Delta U = Q + W$$

$$5400 = Q - 3600$$

$$Q = 9000 \text{ J}$$

9000 J of heat is added

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(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?

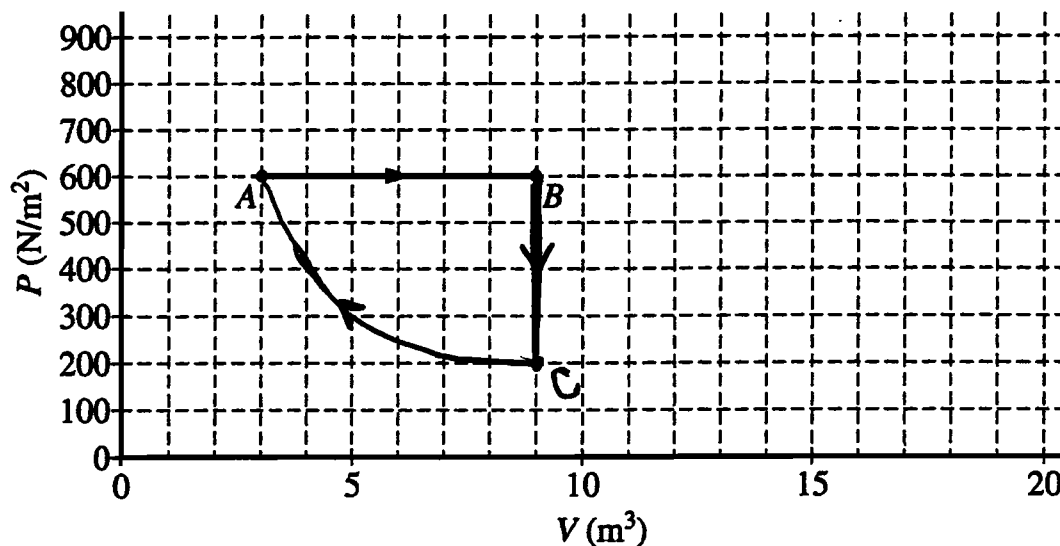
_____ added to removed from

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 $0 = Q + W$

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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.

$$W = -P \Delta V$$

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

$$W = -3600 \text{ J}$$

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.

$$\Delta U = Q + W$$

$$\Delta U - W = Q$$

$$5400 - (-3600) = Q$$

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

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(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.

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

↑
Isothermal

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