AP® Physics B
1999 Sample Student Responses

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$PV = nRT$ $\quad \Delta P = 0$ $\quad Pa = N/m^2$

(10 points)

A cylinder contains 2 moles of an ideal monatomic gas that is initially at state A with a volume of 1.0×10^{-2} m^3 and a pressure of 4.0×10^5 Pa. The gas is brought isobarically to state B, where the volume is 2.0×10^{-2} m^3. The gas is then brought at constant volume to state C, where its temperature is the same as at state A. The gas is then brought isothermally back to state A. $\Delta V = C$

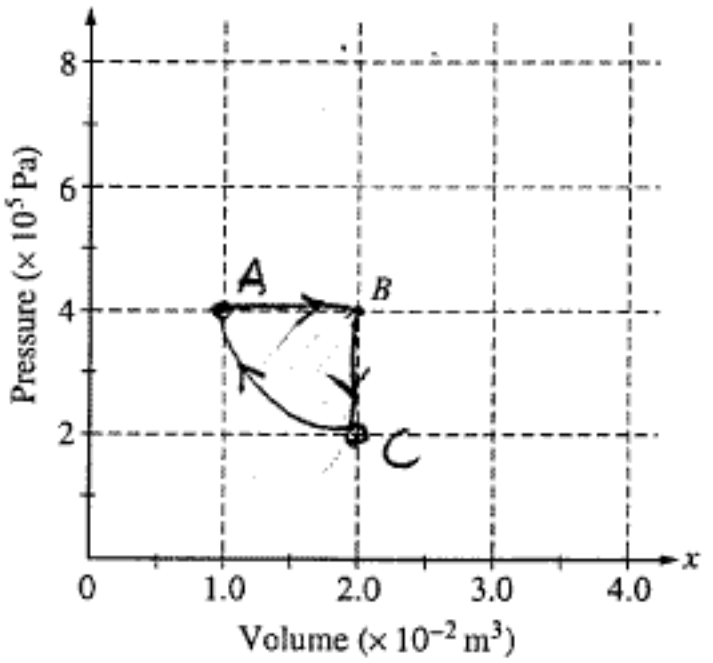
$T_c = T_A$

(a) Determine the pressure of the gas at state C.

$$P = \frac{nRT}{V} = \frac{2 \cdot 8.31 \cdot 240.674\,^\circ K}{2.0 \times 10^{-2} m^3} = 200{,}000\ Pa = 2 \times 10^5 Pa$$

$$T_a = \frac{PV}{nR} = \frac{4.0 \times 10^5\ Pa \cdot 1 \times 10^{-2} m^3}{2\ mol \cdot 8.31\ J/mol \cdot k} = 240.674\,^\circ K$$

(b) On the axes below, state B is represented by the point B. Sketch a graph of the complete cycle. Label points A and C to represent states A and C, respectively.



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(c) State whether the net work done by the gas during the complete cycle is positive, negative, or zero. Justify your answer.

Net work = $W_{AB} + W_{BC} + W_{AC}$
↑ greater positive, = zero, 2 neg

The work is positive b/c the work to get from a to B is more (area under P/V curve) than the AB work (area under curve)

(d) State whether this device is a refrigerator or a heat engine. Justify your answer.

a heat engine b/c it does positive work and ends up at the starting temperature

7. (10 points)
A cylinder contains 2 moles of an ideal monatomic gas that is initially at state A with a volume of 1.0×10^{-2} m^3 and a pressure of 4.0×10^5 Pa. The gas is brought isobarically to state B, where the volume is 2.0×10^{-2} m^3. The gas is then brought at constant volume to state C, where its temperature is the same as at state A. The gas is then brought isothermally back to state A.

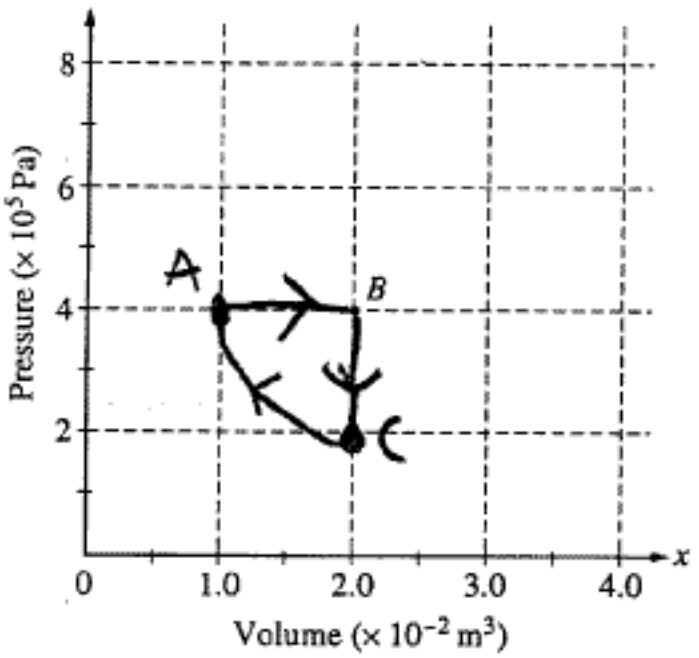
(a) Determine the pressure of the gas at state C.

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

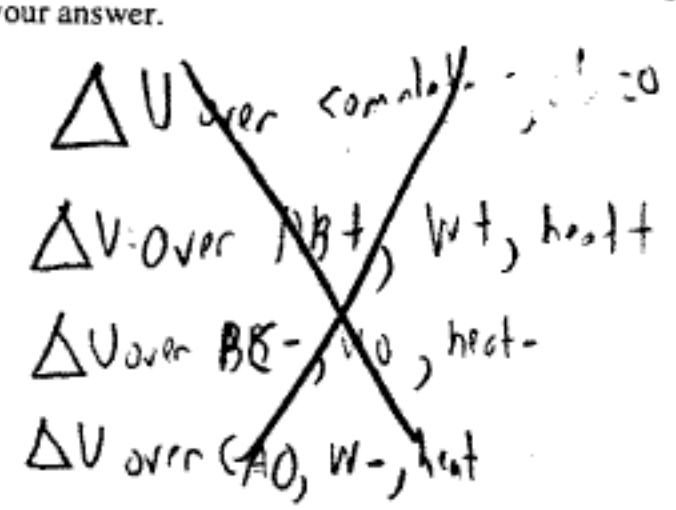
$$(4 \times 10^5)(1 \times 10^{-2}) = P(2 \times 10^{-2})$$

$$\boxed{P = 2 \times 10^5 \text{ Pa}}$$

(b) On the axes below, state B is represented by the point B. Sketch a graph of the complete cycle. Label points A and C to represent states A and C, respectively.



(c) State whether the net work done by the gas during the complete cycle is positive, negative, or zero. Justify your answer.



Net work is positive, because the area under the graph when positive work is done (AB) is greater than the area under the graph when negative work is done (CA).

(d) State whether this device is a refrigerator or a heat engine. Justify your answer.

The device is a refrigerator; a heat engine has four steps in its process (isothermal, adiabatic, isothermal, adiabatic). The fact that there's no adiabatic process aka. excludes the process from being a heat engine

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