AP® Physics B Free-Response Scoring Guidelines

Question 5 10 points total **Distribution** of points (a) (i) 1 point For the correct use of the ideal gas law to find the temperature of the gas in state 1 1 point $P_1V_1 = nRT_1$ $T_1 = P_1 V_1 / nR$ 2 points (ii)For the correct application of the ideal gas law at states 3 and 1 1 point $\frac{PV}{T} = nR = \text{const}$, so $\frac{P_3V_3}{T_2} = \frac{P_1V_1}{T_1}$ For correct substitutions of $T_3 = T_1$ and $V_3 = \frac{V_1}{2}$ to arrive at the correct answer 1 point $P_3 \frac{V_1}{2} = P_1 V_1$ $P_3 = 2P_1$ (iii) 2 points $W = -P\Delta V$ For recognition that for process $2 \rightarrow 3$, $\Delta V = 0$, so $W_{2\rightarrow 3} = 0$ 1 point For the correct expression for the work done on the gas during process $1 \rightarrow 2$ 1 point $W_{1\to 2} = -P_1 \left(\frac{V_1}{2} - V_1 \right) = \frac{P_1 V_1}{2}$ $W_{tot} = W_{1 \to 2} + W_{2 \to 3} = \frac{P_1 V_1}{2} + 0$ $W_{tot} = \frac{P_1 V_1}{2}$ (b) 3 points For indicating that heat is added to the gas 1 point For a correct justification 2 points For example: From the first law of thermodynamics, $\Delta U = Q + W$, it follows that $Q = \Delta U - W$. During process $2 \rightarrow 3$ the volume is constant, so $W = -p\Delta V = 0$. The temperature increases and the internal energy is proportional to temperature, so ΔU is positive. Therefore Q is positive. Heat must be added to increase the

Note: 1 point partial credit may be given for a partially correct answer.

internal energy.

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Question 5 (continued)

Distribution

For indicating that heat is added to the gas 1 point	oints
For a correct justification 1 point For example: From the first law of thermodynamics it follows that $Q = \Delta U - W$. Process $3 \rightarrow 1$ is isothermal and since the internal energy is proportional to temperature, $\Delta U = 0$. Therefore $Q = -W = -(-p\Delta V) = p\Delta V$. Since V increases, ΔV is positive. Therefore Q is positive. Heat must be added to maintain the internal energy.	