

(b) During step I, the change in internal energy is zero. Explain why.

$$Q = \Delta U - W$$

$$= \frac{3}{2}nR\Delta T - P\Delta V$$

\therefore change in internal energy (ΔU) = $\frac{3}{2}nR\Delta T$, because $\Delta T = 0$, there is no change in internal energy.

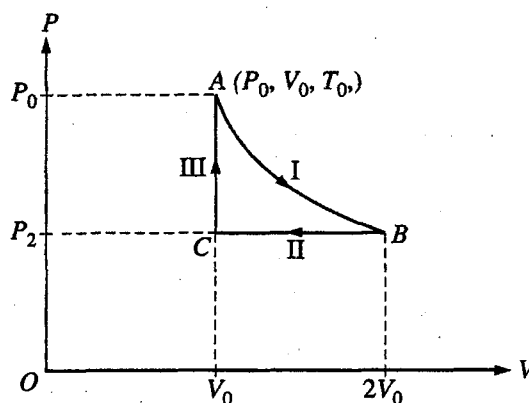
(c) During step III, the work done on the gas is zero. Explain why.

$$Q = \Delta U - W$$

$$= \frac{5}{2}nR\Delta T - P\Delta V$$

Work done on the gas (W) = $P\Delta V$, because $\Delta V = 0$, there is no work done on the gas

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5. (10 points)

A sample of ideal gas is taken through steps I, II, and III in a closed cycle, as shown on the pressure P versus volume V diagram above, so that the gas returns to its original state. The steps in the cycle are as follows.

- I. An isothermal expansion occurs from point A to point B , and the volume of the gas doubles.
- II. An isobaric compression occurs from point B to point C , and the gas returns to its original volume.
- III. A constant volume addition of heat occurs from point C to point A and the gas returns to its original pressure.

(a) Determine numerical values for the following ratios, justifying your answers in the spaces next to each ratio.

i. $\frac{P_B}{P_A} = \frac{1}{2}$

isothermal \Rightarrow constant temperature
 $pV = \text{constant}$

$$P_1 V_1 = P_2 V_2 \text{ or } P_A V_0 = P_B (2V_0)$$

$$\Rightarrow \frac{P_B}{P_A} = \frac{V_0}{2V_0} = \frac{1}{2}$$

ii. $\frac{P_C}{P_A} =$

from B to C

iii. $\frac{T_B}{T_A} = 1$

because AB is an isothermal expansion, so temperature does not change

iv. $\frac{T_C}{T_A} = \frac{1}{2}$

from B to C, volume is halved

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

GO ON TO THE NEXT PAGE.

(b) During step I, the change in internal energy is zero. Explain why.

$$\Delta U = nR\Delta T$$

the change in temperature is zero (isothermal)

$\Rightarrow \Delta U$ is zero
↑
change in
internal
energy

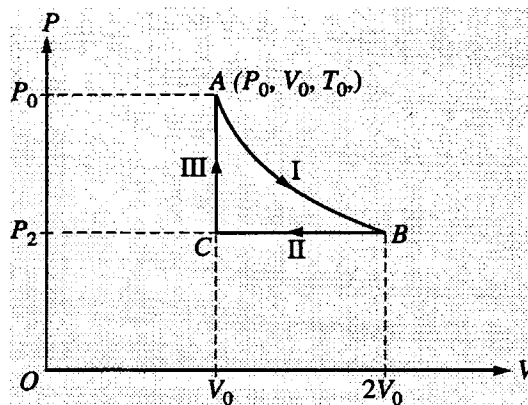
(c) During step III, the work done on the gas is zero. Explain why.

$$W = -P\Delta V$$

the change in volume is zero (isochoric)

$\Rightarrow W$ is zero
↑
work done
on gas

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5. (10 points)

A sample of ideal gas is taken through steps I, II, and III in a closed cycle, as shown on the pressure P versus volume V diagram above, so that the gas returns to its original state. The steps in the cycle are as follows.

- I. An isothermal expansion occurs from point A to point B , and the volume of the gas doubles.
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- III. A constant volume addition of heat occurs from point C to point A and the gas returns to its original pressure.

(a) Determine numerical values for the following ratios, justifying your answers in the spaces next to each ratio.

i. $\frac{P_B}{P_A} = \frac{1}{2}$

because $PV_B = PV_A \Rightarrow \frac{P_B}{P_A} = \frac{V_A}{V_B}$

ii. $\frac{P_C}{P_A} = 2$

$\frac{P_C}{T_C} = \frac{P_A}{T_A} \Rightarrow \frac{P_C}{P_A} = \frac{T_C}{T_A}$

iii. $\frac{T_B}{T_A} = 2$

because it's isothermal

iv. $\frac{T_C}{T_A} = 2$

because it must get an additional heat to return to P_0

GO ON TO THE NEXT PAGE.

(b) During step I, the change in internal energy is zero. Explain why.

(c) During step III, the work done on the gas is zero. Explain why.

because it is isovolumetric

$$W = P\Delta V \quad \text{since } \Delta V \text{ is } 0 \quad W = 0$$

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AP[®] PHYSICS B
2006 SCORING COMMENTARY (Form B)

Question 5

Sample: B5A
Score: 10

In part (a)(iv) the student does not use the fact that states *A* and *C* have the same volume. Instead, the temperature is determined using the fact that states *B* and *C* have the same pressure.

Sample: B5B
Score: 8

The only credit lost was for part (a)(ii), where no solution is attempted. The student takes the same approach to part (a)(iv) described above.

Sample: B5C
Score: 3

Part (a) only earned credit for the correct answer to (i). Part (b) earned nothing, and part (c) received full credit.