



## AP<sup>®</sup> Physics B 2003 Sample Student Responses

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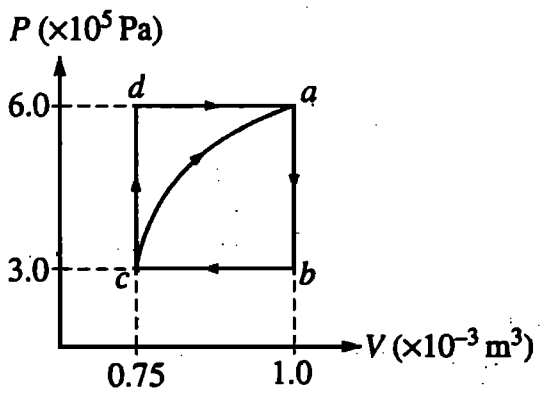
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5. (10 points)

A cylinder with a movable piston contains 0.1 mole of a monatomic ideal gas. The gas, initially at state *a*, can be taken through either of two cycles, *abca* or *abcda*, as shown on the *PV* diagram above. The following information is known about this system.

$$Q_{c \rightarrow a} = 685 \text{ J along the curved path}$$

$$W_{c \rightarrow a} = -120 \text{ J along the curved path}$$

$$U_a - U_b = 450 \text{ J}$$

$$W_{a \rightarrow b \rightarrow c} = 75 \text{ J}$$

(a) Determine the change in internal energy,  $U_a - U_c$ , between states *a* and *c*.

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

$$\Delta U = \frac{3}{2} (0.1) (8.31) (722.02166 - 270.7581227)$$

$$\Delta U = 562.5 \text{ J}$$

(b) i. Is heat added to or removed from the gas when the gas is taken along the path *abc*?

added to the gas

removed from the gas

ii Calculate the amount added or removed.

$$\Delta U = Q + W$$

$$-562.5 = Q + 75$$

$$\boxed{637.5 = Q}$$

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(c) How much work is done on the gas in the process  $cda$ ?

$$W = -6.0 \times 10^5 \cdot 25 \times 10^{-3}$$

$$W = -150 \text{ J}$$

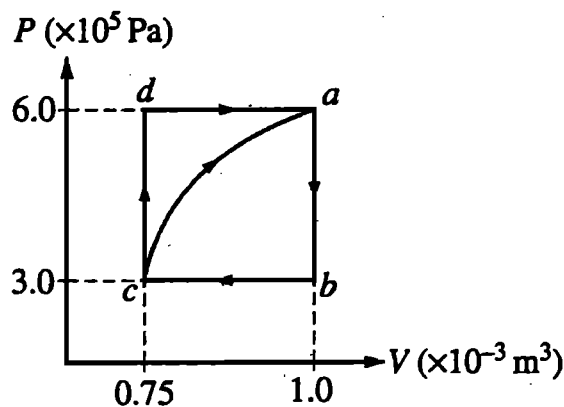
(d) Is heat added to or removed from the gas when the gas is taken along the path  $cda$ ?

added to the gas       removed from the gas

Explain your reasoning.

It must have a total energy greater than that at point C at point A. Because it is doing work and losing energy during this phase the excess energy must be added as heat.

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5. (10 points)

A cylinder with a movable piston contains 0.1 mole of a monatomic ideal gas. The gas, initially at state  $a$ , can be taken through either of two cycles,  $abca$  or  $abcd$ , as shown on the  $PV$  diagram above. The following information is known about this system.

$Q_{c \rightarrow a} = 685 \text{ J}$  along the curved path

$W_{c \rightarrow a} = -120 \text{ J}$  along the curved path

$U_a - U_b = 450 \text{ J}$

$W_{a \rightarrow b \rightarrow c} = 75 \text{ J}$

(a) Determine the change in internal energy,  $U_a - U_c$ , between states  $a$  and  $c$ .

$\Delta U = \Delta Q + \Delta W$

$W_{a \rightarrow b \rightarrow c} = 75 \text{ J}$

For path  $a \rightarrow b \rightarrow c$ :  $\Delta U = \Delta Q + 75 \text{ J}$

$\Delta U_{a \rightarrow b \rightarrow c \rightarrow a} = 0 \text{ J}$

$\Delta U_{c \rightarrow a} = Q_{c \rightarrow a} + W_{c \rightarrow a}$

$\Delta U_{c \rightarrow a} = 685 - 120 = 565 \text{ J}$

(b) i. Is heat added to or removed from the gas when the gas is taken along the path  $abc$ ?

\_\_\_\_\_ added to the gas       removed from the gas

ii Calculate the amount added or removed.

$\Delta U_{c \rightarrow a} + \Delta U_{a \rightarrow b \rightarrow c} = 0$

$565 + \Delta U_{a \rightarrow b \rightarrow c} = 0$

$\therefore \Delta U_{a \rightarrow b \rightarrow c} = -565$

$\Delta U = \Delta Q + \Delta W$

$-565 = \Delta Q + 75$

$-640 \text{ J} = \Delta Q$

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640 J of Heat was removed

X2

(c) How much work is done on the gas in the process *cda*?

$$W = -P\Delta V \quad \Delta V_{c \rightarrow d} = 0$$

$$W_{c \rightarrow d} = -P\Delta V_{c \rightarrow d} = 0$$

$$P_{d \rightarrow a} = 6 \times 10^5$$

$$\Delta V_{d \rightarrow a} = 0.25 \times 10^{-3}$$

$$W_{d \rightarrow a} = -6 \cdot 10^5 \cdot 0.25 \times 10^{-3} = -1.5 \times 10^2 = -150$$

$$W_{c \rightarrow d} + W_{d \rightarrow a} = W_{cda} = -150 \text{ J}$$

(d) Is heat added to or removed from the gas when the gas is taken along the path *cda*?

added to the gas       removed from the gas

Explain your reasoning.

because if work from  $a \rightarrow b \rightarrow c$   
 was 75 and work from  $c \rightarrow a \rightarrow a$   
 was -150  
 75 J of heat was added from  $c \rightarrow d \rightarrow a$ .

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