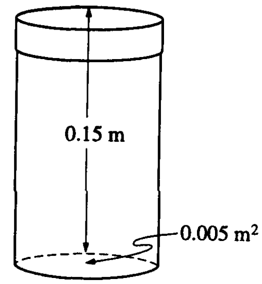
AP Physics Free Response Practice – Thermodynamics

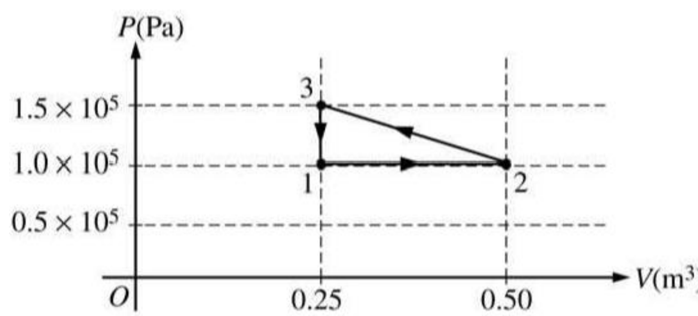


1996B7 The inside of the cylindrical can shown above has cross-sectional area 0.005 m^2 and length 0.15 m. The can is filled with an ideal gas and covered with a loose cap. The gas is heated to 363 K and some is allowed to escape from the can so that the remaining gas reaches atmospheric pressure (1.0×10^5 Pa). The cap is now tightened, and the gas is cooled to 298 K.

a. What is the pressure of the cooled gas?

b. Determine the upward force exerted on the cap by the cooled gas inside the can.

c. If the cap develops a leak, how many moles of air would enter the can as it reaches a final equilibrium at 298 K and atmospheric pressure? (Assume that air is an ideal gas.)



2006B5 A cylinder with a movable frictionless piston contains an ideal gas that is initially in state 1 at 1×10^5 Pa, 373 K, and 0.25 m^3. The gas is taken through a reversible thermodynamic cycle as shown in the *PV* diagram above.

a. Calculate the temperature of the gas when it is in the following states.

i. State 2

ii. State 3

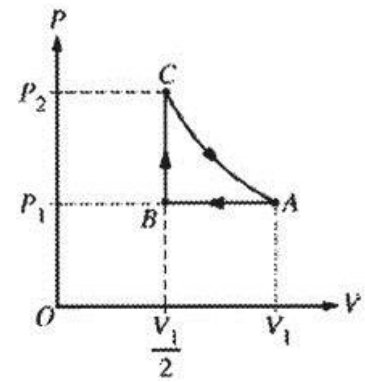
b. Calculate the net work done on the gas during the cycle.

c. Was heat added to or removed from the gas during the cycle?

Added _____ Removed _____ Neither added nor removed _____

Justify your answer.

2004Bb5 One mole of an ideal gas is initially at pressure P_1, volume V_1, and temperature T_1, represented by point *A* on the *PV* diagram above. The gas is taken around cycle *ABCA* shown. Process *AB* is isobaric, process *BC* is isochoric, and process *CA* is isothermal.



a. Calculate the temperature T_2 at the end of process *AB* in terms of temperature T_1.

b. Calculate the pressure P_2 at the end of process *BC* in terms of pressure P_1.

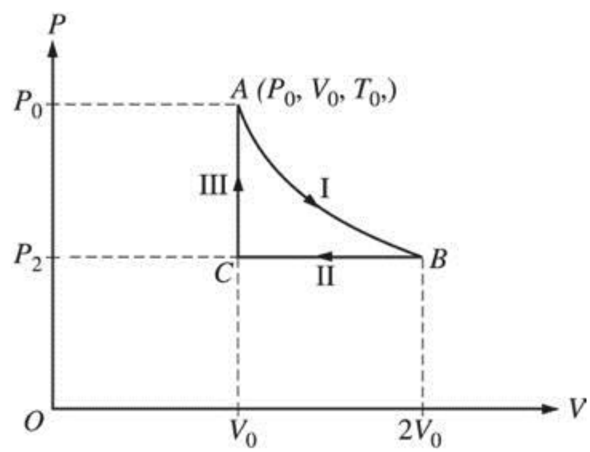
c. Calculate the net work done on the gas when it is taken from *A* to *B* to *C*. Express your answer in terms of P_1 and V_1.

d. Indicate below all of the processes that result in heat being added to the gas.

____ *AB* ____ *BC* ____ *CA*

Justify your answer.

2006Bb5. 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. $\frac{P_B}{P_A} =$ ii. $\frac{P_C}{P_A} =$ iii. $\frac{T_B}{T_A} =$ iv. $\frac{T_C}{T_A} =$

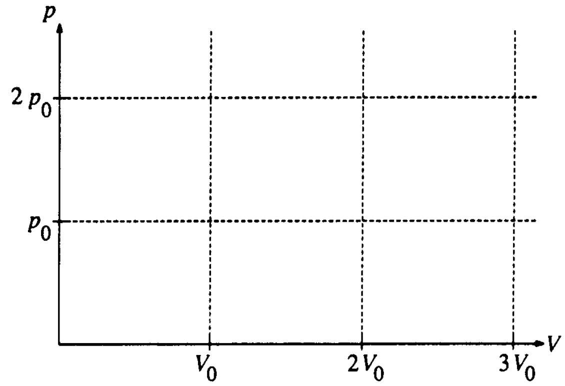
b. During step I, the change in internal energy is zero. Explain why.

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

1989B4 (modified) An ideal gas initially has pressure p_o, volume V_o, and absolute temperature T_o. It then undergoes the following series of processes:

I. It is heated, at constant volume, until it reaches a pressure $2p_o$.
II. It is heated, at constant pressure, until it reaches a volume $3\ V_o$.
III. It is cooled, at constant volume, until it reaches a pressure p_o.
IV. It is cooled, at constant pressure, until it reaches a volume V_o.

a. On the axes below
i. draw the p-V diagram representing the series of processes;
ii. label each end point with the appropriate value of absolute temperature in terms of T_o.

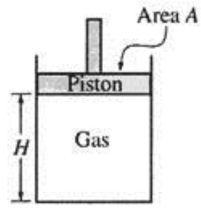


b. For this series of processes, determine the following in terms of p_o and V_o.
i. The net work done on the gas

ii. The net change in internal energy

iii. The net heat absorbed

c. Determine the heat transferred during process 2 in terms of p_o and V_o.

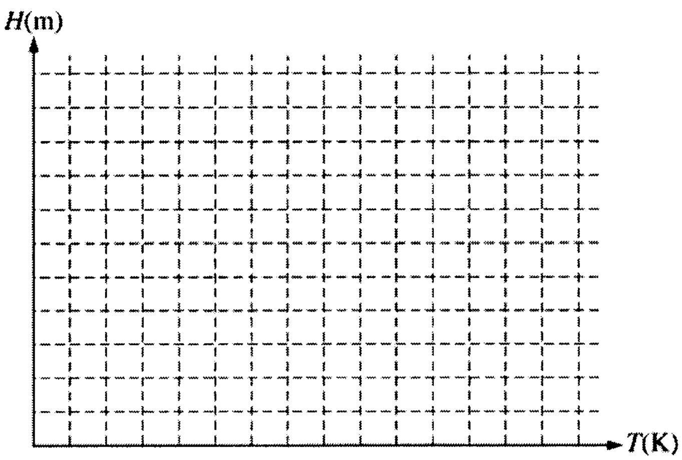


T (K)	H (m)
300	1.11
325	1.19
355	1.29
375	1.37
405	1.47

2005B6. An experiment is performed to determine the number n of moles of an ideal gas in the cylinder shown above. The cylinder is fitted with a movable, frictionless piston of area A. The piston is in equilibrium and is supported by the pressure of the gas. The gas is heated while its pressure P remains constant. Measurements are made of the temperature T of the gas and the height H of the bottom of the piston above the base of the cylinder and are recorded in the table below. Assume that the thermal expansion of the apparatus can be ignored.

a. Write a relationship between the quantities T and H, in terms of the given quantities and fundamental constants, that will allow you to determine n.

b. Plot the data on the axes below so that you will be able to determine n from the relationship in part (a). Label the axes with appropriate numbers to show the scale.



c. Using your graph and the values A = 0.027 m^2 and P = 1.0 atmosphere, determine the experimental value of n.

1995B5. A heat engine operating between temperatures of 500 K and 300 K is used to lift a 10-kilogram mass vertically at a constant speed of 4 meters per second.

a. Determine the power that the engine must supply to lift the mass.

b. Determine the maximum possible efficiency at which the engine can operate.

c. If the engine were to operate at the maximum possible efficiency, determine the following.

i. The rate at which the hot reservoir supplies heat to the engine

ii. The rate at which heat is exhausted to the cold reservoir