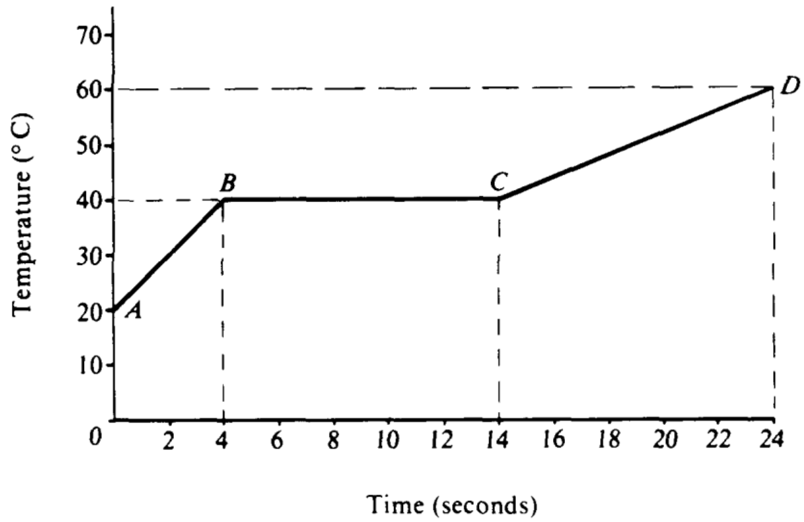


1985B4. A 0.020-kilogram sample of a material is initially a solid at a temperature of 20° C. Heat is added to the sample at a constant rate of 100 joules per second until the temperature increases to 60° C. The graph above represents the temperature of the sample as a function of time.

a. Calculate the specific heat of the solid sample in units of joules per kilogram°C.

b. Calculate the latent heat of fusion of the sample at its melting point in units of joules per kilogram.

c. Referring to the three intervals AB, BC, and CD shown on the graph, select the interval or intervals
on the graph during which:
i. the average kinetic energy of the molecules of the sample is increasing
ii. the entropy of the sample is increasing

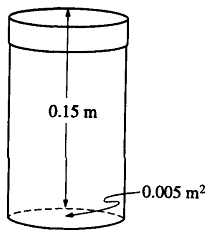
1987B3. A freezer contains 20 kilograms of food with a specific heat of 2×10^3 J/kg°C. The temperature inside the freezer is initially -5º C. The freezer motor then operates for 10 minutes, reducing the temperature to - 8° C.

a. How much heat is removed from the food during this time? The freezer motor operates at 400 watts.

b. How much energy is delivered to the freezer motor during the 10-minute period?

c. During this time, how much total heat is ejected into the room in which the freezer is located?

d. Determine the temperature change in the room if the specific heat of air is 700 J/kg°C Assume there are 80 kilograms of air in the room, the volume of the air is constant, and there is no heat loss from the room.

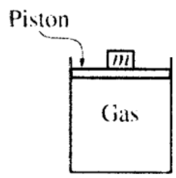


1996B7 (10 points) The inside of the cylindrical can shown above has cross-sectional area 0.005 M2 and length 0.15 m. The can is filled with an ideal gas and covered with a loose cap. The gas is heated to 363 K and some is allowed to escape from the can so that the remaining gas reaches atmospheric pressure (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.)



Note: Figure not drawn to scale.

B2005B6. (10 points) You are given a cylinder of cross-sectional area A containing n moles of an ideal gas. A piston fitting closely in the cylinder is lightweight and frictionless, and objects of different mass m can be placed on top of it, as shown in the figure above. In order to determine n, you perform an experiment that consists of adding 1 kg masses one at a time on top of the piston, compressing the gas, and allowing the gas to return to room temperature T before measuring the new volume V. The data collected are given in the table below.

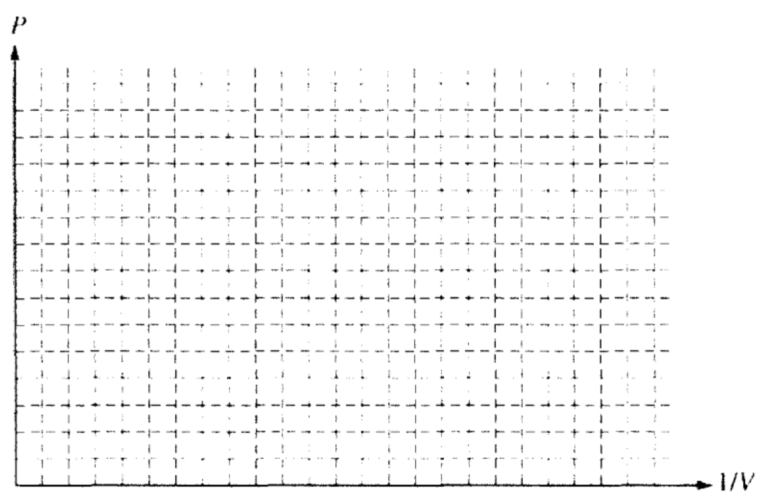
m (kg)	$V\left(\text{m}^3\right)$	$1/V\left(\text{m}^{-3}\right)$	P (Pa)
0	6.0×10^{-5}	1.7×10^4	
1	4.5×10^{-5}	2.2×10^4	
2	3.6×10^{-5}	2.8×10^4	
3	3.0×10^{-5}	3.3×10^4	
4	2.6×10^{-5}	3.8×10^4	

(a) Write a relationship between total pressure P and volume V in terms of the given quantities and fundamental constants that will allow you to determine n.

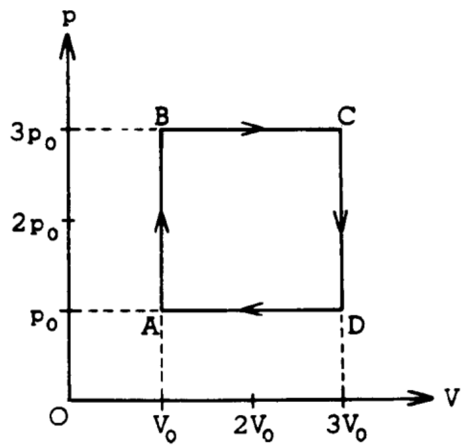
You also determine that $A = 3.0 \times 10^{-4}$ m and $T = 300$ K.

(b) Calculate the value of P for each value of m and record your values in the data table above.

(c) Plot the data on the graph below, labeling the axes with appropriate numbers to indicate the scale.



(d) Using your graph in part (c), calculate the experimental value of n.



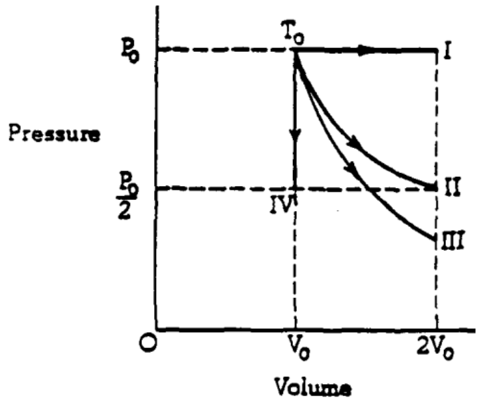
1975B3. One mole of a monatomic ideal gas enclosed in a cylinder with a movable piston undergoes the process ABCDA shown on the p-V diagram above.

a. In terms of p_o and V_o calculate the work done by the gas in the process.

b. In terms of p_o and V_o calculate the net heat absorbed by the gas in the process.

c. At what two lettered points in the process are the temperatures equal? Explain your reasoning.

d. Consider the segments AB and BC. In which segment is the amount of heat added greater? Explain your reasoning.



1979B5. Four samples of ideal gas are each initially at a pressure P_o and volume V_o, and a temperature T_o as shown on the diagram above. The samples are taken in separate experiment from this initial state to the final states I, II, III, and IV along the processes shown on the diagram.

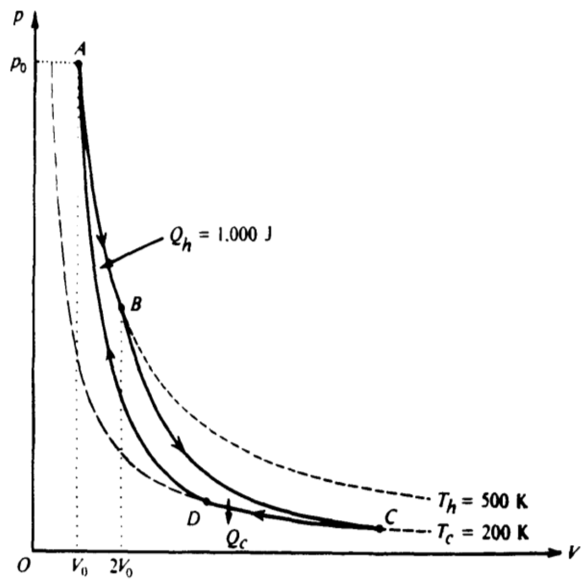
a. One of the processes is isothermal. Identify which one and explain.

b. One of the processes is adiabatic. Identify this one and explain.

c. in which process or processes does the gas do work? Explain.

d. In which process or processes is heat removed from the gas? Explain.

e. In which process or processes does the root-mean-square speed of the gas molecules increase? Explain.



1983B4. The p V-diagram above represents the states of an ideal gas during one cycle of operation of a reversible heat engine. The cycle consists of the following four processes.

Process	**Nature of Process**
AB	Constant temperature (T_h = 500 K)
BC	Adiabatic
CD	Constant temperature (T_c = 200 K)
DA	Adiabatic

During process A B, the volume of the gas increases from V_o to $2V_o$ and the gas absorbs 1,000 joules of heat.

a. The pressure at A is $p_{o.}$ Determine the pressure at B.

b. Using the first law of thermodynamics, determine the work performed by or on the gas during the process A B.

c. During the process AB, does the entropy of the gas increase, decrease, or remain unchanged? Justify your answer.

d. Calculate the heat Q_c given off by the gas in the process CD.

e. During the full cycle ABCDA is the total work the gas performs on its surroundings positive, negative, or zero? Justify your answer.

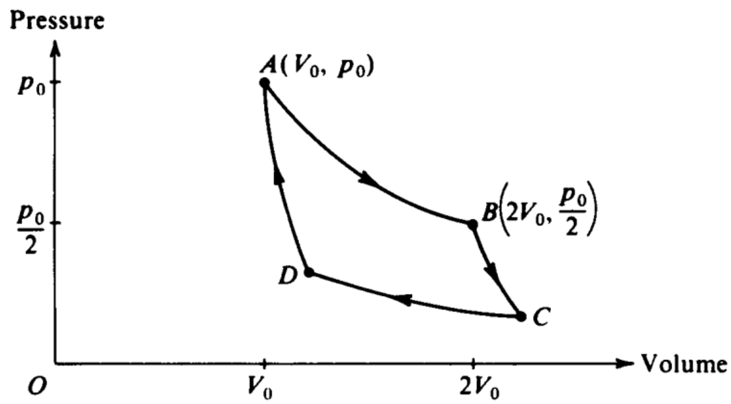
1986B5. A proposed ocean power plant will utilize the temperature difference between surface seawater and seawater at a depth of 100 meters. Assume the surface temperature is 25° Celsius and the temperature at the 100-meter depth is 3° Celsius.

a. What is the ideal (Carnot) efficiency of the plant?

b. If the plant generates useful energy at the rate of 100 megawatts while operating with the efficiency found in part (a), at what rate is heat given off to the surroundings?

c. A nuclear power plant operates with an overall efficiency of 40 percent. At what rate must mass be converted into energy to give the same 100-megawatt output as the ocean power plant above? Express your answer in kilograms per second.

The diagram below represents the Carnot cycle for a simple reversible (Carnot) engine in which a fixed amount of gas, originally at pressure p_o and volume V_o follows the path ABCDA.



d. In the chart below, for each part of the cycle indicate with +, -, or 0 whether the heat transferred Q and temperature change ΔT are positive, negative, or zero, respectively. (Q is positive when heat is added to the gas, and ΔT is positive when the temperature of the gas increases.)

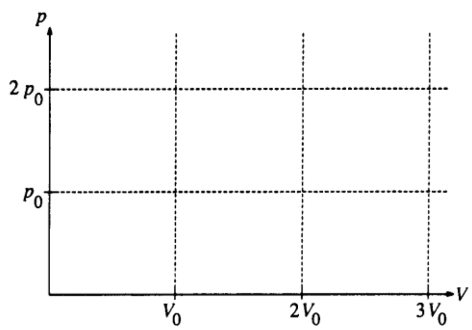
	Q	ΔT
AB		
BC		
CD		
DA		

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

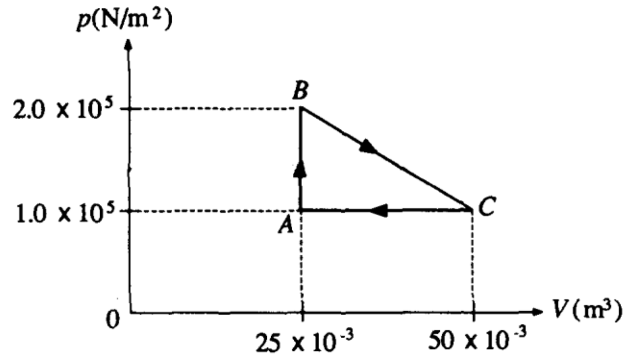
I. It is heated, at constant volume, until it reaches a pressure $2p_o$.
II. It is heated, at constant pressure, until it reaches a volume $3\ V_o$.
III. It is cooled, at constant volume, until it reaches a pressure p_o.
IV. It is cooled, at constant pressure, until it reaches a volume V_o.

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 by the gas
  ii. The net change in internal energy
  iii. The net heat absorbed

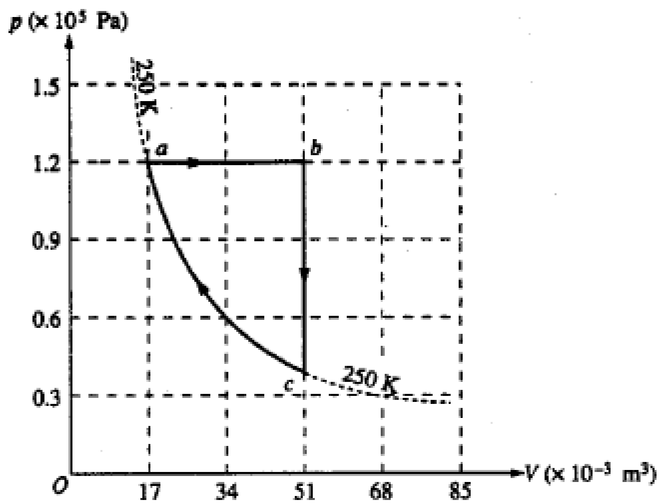


c. Given that $C_p = (5/2)R$ and $C_v = (3/2)R$, determine the heat transferred during process 2 in terms of p_o and V_o.



1990B4. One mole of an ideal monatomic gas, initially at point A at a pressure of 1.0×10^5 newtons per meter squared and a volume of 25×10^{-3} meter cubed, is taken through a 3-process cycle, as shown in the pV diagram above. Each process is done slowly and reversibly. For a monatomic gas, the heat capacities for constant volume and constant pressure are, respectively, $C_v = (3/2)R$ and $C_p = (5/2)R$, where R is the universal gas constant, 8.32 J/mole K. Determine each of the following:

a. the temperature of the gas at each of the vertices, A, B. and C, of the triangular cycle
b. the net work done by the gas for one cycle
c. the net heat absorbed by the gas for one full cycle
d. the heat given off by the gas for the third process from C to A
e. the efficiency of the cycle



1993B5. One mole of an ideal monatomic gas is taken through the cycle abca shown on the diagram above. State a has volume $V_a = 17 \times 10^{-3}$ cubic meter and pressure $P_a = 1.2 \times 10^5$ pascals, and state c has volume $V_c = 51 \times 10^{-3}$ cubic meter. Process ca lies along the 250 K isotherm. The molar heat capacities for the gas are $C_p = 20.8$ J/mole K, and $C_v = 12.5$ J/mole K. Determine each of the following.

a. The temperature T_b of state b

b. The heat Q_{ab} added to the gas during process ab

c. The change in internal energy $U_b - U_a$

d. The work W_{bc} done by the gas on its surroundings during process bc

The net heat added to the gas for the entire cycle 1,800 joules. Determine each of the following.

e. The net work done by the gas on its surroundings for the entire cycle

f. The efficiency of a Carnot engine that operates between the maximum and minimum temperatures in this cycle

1995B4. (10 points) 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.

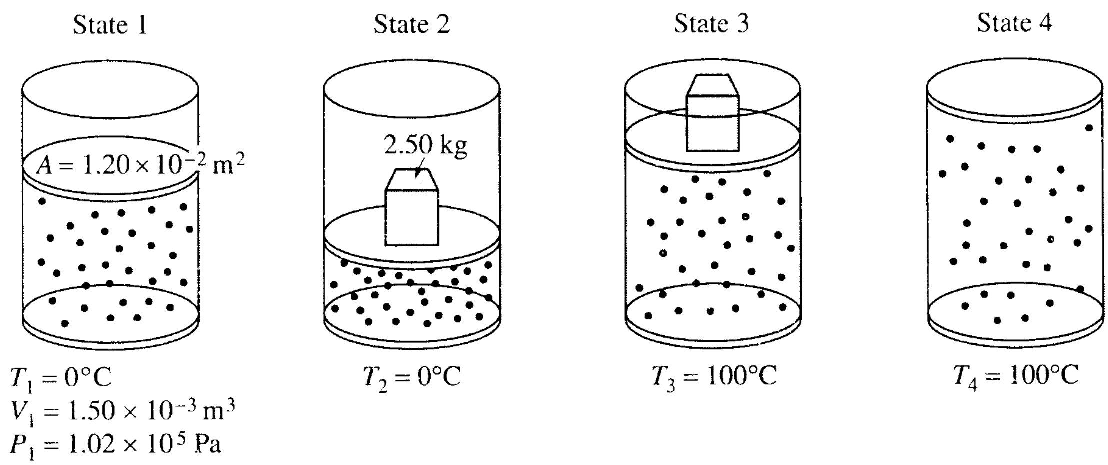
a. Determine the power that the engine must supply to lift the mass.

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



Note: Figures not drawn to scale.

2001B6 (10 points) A cylinder is fitted with a freely moveable piston of area 1.20×10^{-2} m^2 and negligible mass. The cylinder below the piston is filled with a gas. At state 1, the gas has volume 1.50×10^{-3} m^3, pressure 1.02×10^5 Pa, and the cylinder is in contact with a water bath at a temperature of 0°C. The gas is then taken through the following four-step process.

- A 2.50 kg metal block is placed on top of the piston, compressing the gas to state 2, with the gas still at 0°C.
- The cylinder is then brought in contact with a boiling water bath, raising the gas temperature to 100°C at state 3.
- The metal block is removed and the gas expands to state 4 still at 100°C.
- Finally, the cylinder is again placed in contact with the water bath at 0°C, returning the system to state 1.

a. Determine the pressure of the gas in state 2.

b. Determine the volume of the gas in state 2.

c. Indicate below whether the process from state 2 to state 3 is isothermal, isobaric, or adiabatic.

_____Isothermal _____Isobaric

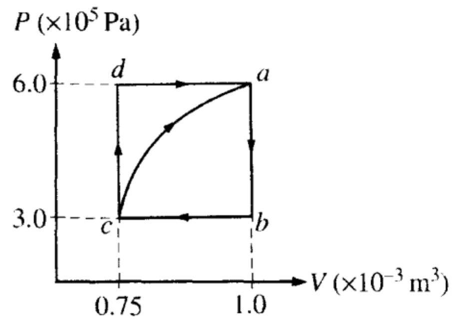
_____Adiabatic

Explain your reasoning.

d. Is the process from state 4 to state 1 isobaric? _____Yes _____No

Explain your reasoning.

e. Determine the volume of the gas in state 4



2003B5. (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 J along the curved path
$W_{c \rightarrow a}$ = -120 J along the curved path
$U_a - U_b$ = 450J
$W_{a \rightarrow b \rightarrow c}$ = 75 J

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

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.

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

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.