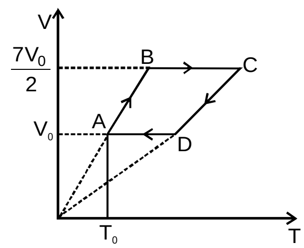
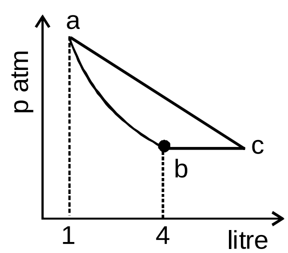
Exercise - IV (TOUGH SUBJECTIVE PROBLEMS)

1. A freely moving piston divides a vertical cylinder, closed at both ends, into two parts each containing 1 mole of air. In equilibrium, at T = 300 K, volume of the upper part in η = 4 times greater than the lower p part. At what temperature will the ratio of these volumes be equal to η' = 2?

2. A sample of an ideal non linear tri-atomic gas has a pressure P_0 and temperature T_0 taken through the cycle as shown starting from A. Pressure for process C $\rightarrow$ D is 3 times P_0. Calculate the heat absorbed in the cycle and work done.

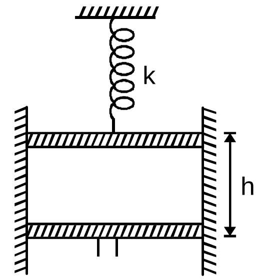


3. Figure shown three processes for an ideal gas. The tempeature at 'a' is 600 K, pressure 16 atm and volume 1 litre. The volume at 'b' is 4 litre. Out of the two process ab and ac, one is adiabatic and he other is isothermal. The ratio of specific heats of the gas is 1.5. Answer the following :

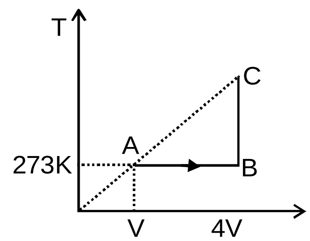


(i) Which of ab and ac processes is adiabatic. Why ?
(ii) Compute the pressure of th gas at b and c.
(iii) Compute the temperature and b and c.
(iv) Compute the volume at c.

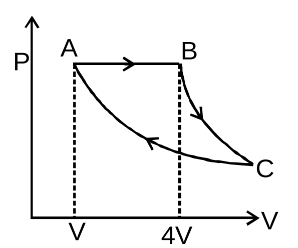
4. An ideal gas NTP is enclosed in a adiabatic vertical cylinder having area of cross section A = 27 cm^2, between two light movable pistons as shown in th figure. Spring with force constant k = 3700 N/m is in a relaxed state initially. Now the lower piston is moved upwards a height h/2, h being the initial length of gas column. It is observed that the upper piston moves up by a distance h/16. Find h taking γ for the gas to be 1.5. Also find the final temperature of the gas.



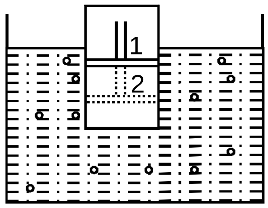
5. At a temperature of T_0 = 273°K, two mols of an ideal gas undergoes a process as shown. The total amount of heat imparted to the gas equals Q = 27.7 kJ. Determine the ratio of molar specific heat capacities.



6. A fixed mass of a gas is taken through a process A $\rightarrow$ B $\rightarrow$ C $\rightarrow$ A. Here A $\rightarrow$ B is isobaric. B $\rightarrow$ C is adiabatic and C $\rightarrow$ A is isothemal. Find efficiency of the process (take γ = 1.5)



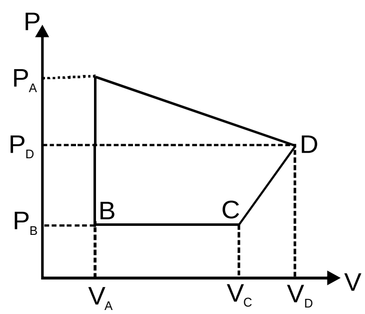
7. A cylinder containing a gas is closed by a movable piston. The cylinder is submerged in an ice-water mixture. The piston is quickly pushed down from position 1 to position 2. The piston is held at position 2 until the gas is again at 0°C and then slowly raised back to position 1. Represent the whole process on P – V diagram. If m = 100 gm of ice are melted during the cycle, how much work is done on the gas. Latent heat of ice = 80 cal/gm.



8. A parallel beam of particles of mass m moving with velocities v impings on a wall at an angle θ to its normal. The number of particles per unit volume in the beam is n. If the collision of particles with the wall is elastic, then find the pressure exerted by this beam on the wall.

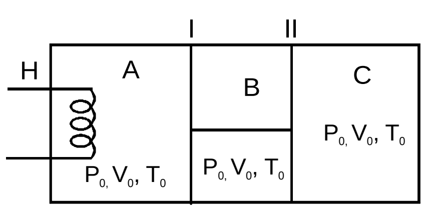
9. For the thermodynamic process shown in the figure.

$P_A = 1 \times 10^5$ Pa ; $P_B = 0.3 \times 10^5$ Pa
$P_D = 0.6 \times 10^5$ Pa ; $V_A = 0.20$ litre
$V_D = 1.30$ litre.



(a) Find the work performed by the system along path AD.
(b) In the total work done by the system along the path ADC is 85 J find the volume a point C.
(c) How much work is perfomed by the system along the path CDA ?

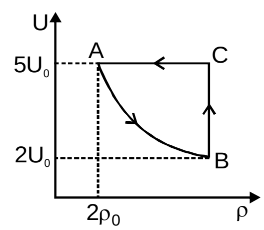
10. The figure shows an insulated cylinder divided into three parts A, B and C. Pistons I and II are connected by a rigid rod and can move without friction inside the cylinder. Piston I is perfectly conducting while piston II si pefectly insulating. The initial state of the gas (γ = 1.5) present in each compartment A, B and C is as shown. Now, compartment A is slowly given heat through a heater H such that the final volume of C becomes $\frac{4V_0}{9}$. Assume the gas to be ideal and find.



(a) Final pressurs in each compartment A, B and C
(b) Final temperatures in each compartment A, B and C
(c) Heat supplied by the heater
(d) Work done by gas in A and B.
(e) Heat flowing across piston I.

11. How many atoms do the molecules of gas consist of if γ increases 1.20 times when the vibrational degrees of freedom are "frozen"? Assume that molecules are non linear.

12. Figure shows the variation of the internal energy U with the density ρ of one mole of idel monoatomic gas for a thermodynamic cycle ABCA.
Here process AB is a part of rectangular hyperbola.

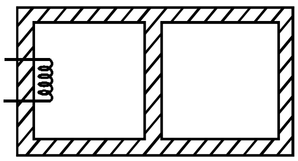


(a) Draw the P-V diagram for the above process.
(b) Find the net amount of heat absorbed by the system for the cyclic process.
(c) Find the work done in the process AB.

13. An ideal monoatomic gas undergoes a process where its pressur is inversely proportional to its tempeature.
(i) Calculate the specific heat for process.
(ii) Find the work done by two moles of gas if the temperature changes from T_1 to T_2.

14. An ideal diatomic gas undergoes a process in which its internal energy ralates to the volume as $U = a\sqrt{V}$ where α is a constant.
(a) Find the work performed by the gas and the amount of heat to be transferred to this gas to increase its internal energy by 100 J.
(b) Find the molar specific heat of the gas for this process.

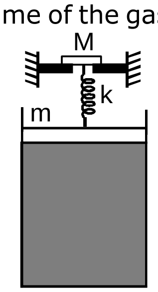
15. Two rectangular boxes shown in figures has a partition which can slide without friction along the length of the box. Initially each of the two chambers of the box has one mole of a monoatomic ideal gas (γ = 5/3) at a pressure p_0 volume V_0 and temperature T_0. The chamber on the left is slowly heated by an electric heater. The walls of the box and the partitions are thermally insulated. Heat loss through the lead wires of the heater is negligible. The gas in the left chamber expands, pushing the partition until the final pressure in both chambers becomes 243 P_0/32 . Determine



(i) the final temperature of the gas in each chamber and

(ii) the work-done by the gas in the right chamber.

16. 0.01 moles of an ideal diatomic gas is enclosed in an adiabatic cylinder of cross-sectional area A = 10^{-4} m^2. In the arrangement shown, a block of mass M = 0.8 kg is placed on a horizontal support, and another block of mass m = 1 kg is suspended from a spring of stiffness constant k = 16 N/m. Initially, the spring is relaxed and the volume of the gas is V = 1.4×10^{-4} m^3



(a) Find the initial pressure of the gas.

(b) If block m is gentily pushed down and released it oscillates harmonically, find its angula frquency of oscillation.

(c) When the gas in the cylinder is heated up the piston starts moving up and the spring gets compressed so that the block M is just lifted up. Determine the heat supplied.

Take atmospheric pressure P_0 = 10^5 Nm^{-2} , g = 10 m/s^2

17. A thermally insulated vessel is divided into two parts by a heat-insulating piston which can move in the vessel without the friction. The left part of the vessel contains one mole of an ideal monatomic gas, & the right part is empty. The piston is connected to the right wall of the vessel through a spring whose length in free state is equal to the length of the vessel as shown in the figure. Determine the heat capacity C of the system, neglecting the heat capacities of the vessel, piston and spring.