Thermodynamics

Very Short Answer Type Questions

1. Can a system be heated and its temperature remains constant?
2. A system goes from P to Q by two different paths in the P-V diagram as shown in Fig. 12.8. Heat given to the system in path 1 is 1000 J. The work done by the system along path 1 is more than path 2 by 100 J. What is the heat exchanged by the system in path 2?

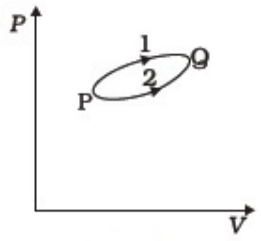

Fig. 12.8

3. If a refrigerator's door is kept open, will the room become cool or hot? Explain.
4. Is it possible to increase the temperature of a gas without adding heat to it? Explain.
5. Air pressure in a car tyre increases during driving. Explain.

Short Answer Type Questions

1. Consider a Carnot's cycle operating between T_1 = 500K and T_2 = 300K producing 1 k J of mechanical work per cycle. Find the heat transferred to the engine by the reservoirs.
2. A person of mass 60 kg wants to lose 5kg by going up and down a 10m high stairs. Assume he burns twice as much fat while going up than coming down. If 1 kg of fat is burnt on expending 7000 kilo calories, how many times must he go up and down to reduce his weight by 5 kg?
3. Consider a cycle tyre being filled with air by a pump. Let V be the volume of the tyre (fixed) and at each stroke of the pump $\Delta V \leq V$)
of air is transferred to the tube adiabatically. What is the work done when the pressure in the tube is increased from P_1 to P_2?

4. In a refrigerator one removes heat from a lower temperature and deposits to the surroundings at a higher temperature. In this process, mechanical work has to be done, which is provided by an electric motor. If the motor is of 1kW power, and heat is transferred from –3°C to 27°C, find the heat taken out of the refrigerator per second assuming its efficiency is 50% of a perfect engine.
5. If the co-efficient of performance of a refrigerator is 5 and operates at the room temperature (27 °C), find the temperature inside the refrigerator.
6. The initial state of a certain gas is (P_i, V_i, T_i). It undergoes expansion till its volume becomes Vf . Consider the following two cases:
   - (a) the expansion takes place at constant temperature.
   - (b) the expansion takes place at constant pressure.

   Plot the P-V diagram for each case. In which of the two cases, is the work done by the gas more?

Long Answer Type Questions

1. Consider a P-V diagram in which the path followed by one mole of perfect gas in a cylindrical container is shown in Fig. 12.9.

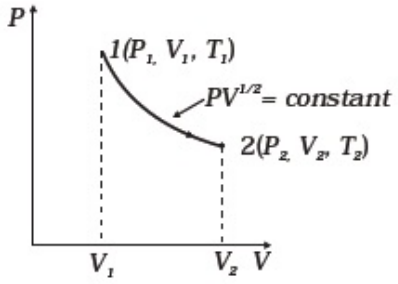

Fig. 12.9

   - (a) Find the work done when the gas is taken from state 1 to state 2.
   - (b) What is the ratio of temperature T_1/T_2, if $V_2 = 2V_1$?
   - (c) Given the internal energy for one mole of gas at temperature T is (3/2) RT, find the heat supplied to the gas when it is taken from state 1 to 2, with $V_2 = 2V_1$.

2. A cycle followed by an engine (made of one mole of perfect gas in a cylinder with a piston) is shown in Fig. 12.10.

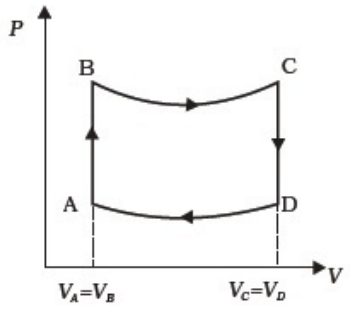

Fig. 12.10

A to B : volume constant

B to C : adiabatic

C to D : volume constant

D to A : adiabatic

$V_C = V_D = 2V_A = 2V_B$

- (a) In which part of the cycle heat is supplied to the engine from outside?
- (b) In which part of the cycle heat is being given to the surrounding by the engine?
- (c) What is the work done by the engine in one cycle? Write your answer in term of P_A, P_B, V_A.
- (d) What is the efficiency of the engine?

  [5 γ = 5 / 3 for the gas], (C_V = 3 / 2 R for one mole)

3. A cycle followed by an engine (made of one mole of an ideal gas in a cylinder with a piston) is shown in Fig. 12.11. Find heat exchanged by the engine, with the surroundings for each section of the cycle. (C_v = (3/2) R)

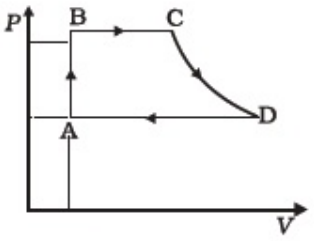

Fig. 12.11

AB : constant volume

BC : constant pressure

CD : adiabatic

DA : constant pressure

4. Consider that an ideal gas (n moles) is expanding in a process given by P = f (V), which passes through a point (V_o, P_o). Show that the gas is absorbing heat at (P_o, V_o) if the slope of the curve P = f (V) is larger than the slope of the adiabat passing through (P_o, V_o).
5. Consider one mole of perfect gas in a cylinder of unit cross section with a piston attached (Fig. 12.12). A spring (spring constant k) is attached (unstretched length L) to the piston and to the bottom of the cylinder. Initially the spring is unstretched and the gas is in equilibrium. A certain amount of heat Q is supplied to the gas causing an increase of volume from V_o to V_1.

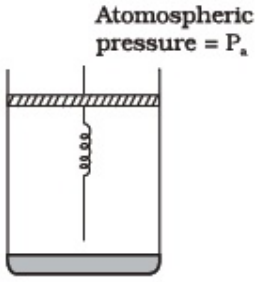

Fig. 12.12

- (a) What is the initial pressure of the system?
- (b) What is the final pressure of the system?
- (c) Using the first law of thermodynamics, write down a relation between Q, P_a, V, V_o and k.