

## Chapter Twelve

## THERMODYNAMICS



## MCQ I

**12.1** An ideal gas undergoes four different processes from the same initial state (Fig. 12.1). Four processes are adiabatic, isothermal, isobaric and isochoric. Out of 1, 2, 3 and 4 which one is adiabatic.

- (a) 4
- (b) 3
- (c) 2
- (d) 1

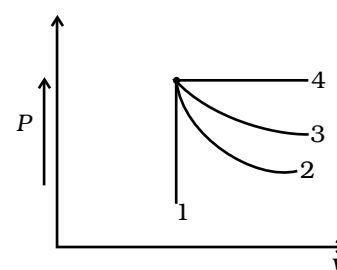


Fig. 12.1

**12.2** If an average person jogs, he produces  $14.5 \times 10^3$  cal/min. This is removed by the evaporation of sweat. The amount of sweat evaporated per minute (assuming 1 kg requires  $580 \times 10^3$  cal for evaporation) is

- (a) 0.25 kg
- (b) 2.25 kg
- (c) 0.05 kg
- (d) 0.20 kg

**Exemplar Problems–Physics**

**12.3** Consider  $P$ - $V$  diagram for an ideal gas shown in Fig 12.2.

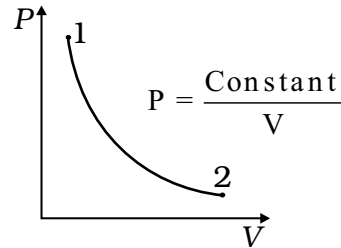


Fig. 12.2

Out of the following diagrams (Fig. 12.3), which represents the  $T$ - $P$  diagram?

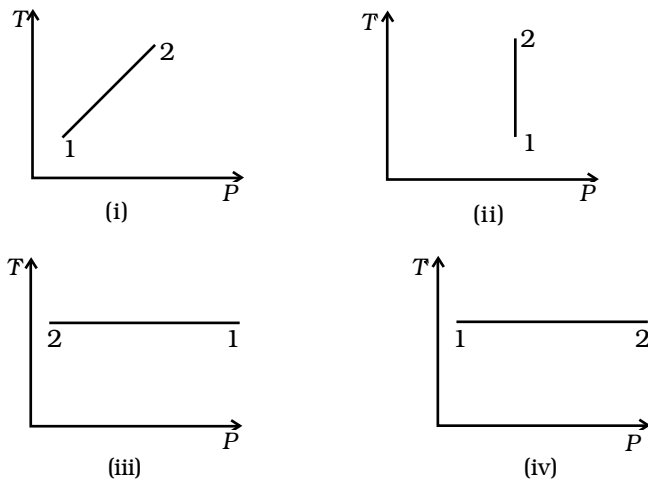


Fig. 12.3

- (a) (iv)
- (b) (ii)
- (c) (iii)
- (d) (i)

**12.4** An ideal gas undergoes cyclic process ABCDA as shown in given  $P$ - $V$  diagram (Fig. 12.4).

The amount of work done by the gas is

- (a)  $6P_0V_0$
- (b)  $-2P_0V_0$
- (c)  $+2P_0V_0$
- (d)  $+4P_0V_0$

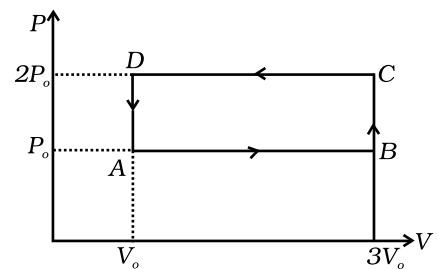


Fig 12.4

- 12.5** Consider two containers A and B containing identical gases at the same pressure, volume and temperature. The gas in container A is compressed to half of its original volume isothermally while the gas in container B is compressed to half of its original value adiabatically. The ratio of final pressure of gas in B to that of gas in A is

(a)  $2^{\gamma-1}$

(b)  $\left(\frac{1}{2}\right)^{\gamma-1}$

(c)  $\left(\frac{1}{1-\gamma}\right)^2$

(d)  $\left(\frac{1}{\gamma-1}\right)^2$

- 12.6** Three copper blocks of masses  $M_1$ ,  $M_2$  and  $M_3$  kg respectively are brought into thermal contact till they reach equilibrium. Before contact, they were at  $T_1$ ,  $T_2$ ,  $T_3$  ( $T_1 > T_2 > T_3$ ). Assuming there is no heat loss to the surroundings, the equilibrium temperature  $T$  is ( $s$  is specific heat of copper)

(a)  $T = \frac{T_1 + T_2 + T_3}{3}$

(b)  $T = \frac{M_1 T_1 + M_2 T_2 + M_3 T_3}{M_1 + M_2 + M_3}$

(c)  $T = \frac{M_1 T_1 + M_2 T_2 + M_3 T_3}{3(M_1 + M_2 + M_3)}$

(d)  $T = \frac{M_1 T_1 s + M_2 T_2 s + M_3 T_3 s}{M_1 + M_2 + M_3}$

## MCQ II

- 12.7** Which of the processes described below are irreversible?
- The increase in temperature of an iron rod by hammering it.
  - A gas in a small container at a temperature  $T_1$  is brought in contact with a big reservoir at a higher temperature  $T_2$  which increases the temperature of the gas.
  - A quasi-static isothermal expansion of an ideal gas in cylinder fitted with a frictionless piston.

**Exemplar Problems–Physics**

(d) An ideal gas is enclosed in a piston cylinder arrangement with adiabatic walls. A weight  $W$  is added to the piston, resulting in compression of gas.

**12.8** An ideal gas undergoes isothermal process from some initial state  $i$  to final state  $f$ . Choose the correct alternatives.

- (a)  $dU = 0$
- (b)  $dQ = 0$
- (c)  $dQ = dU$
- (d)  $dQ = dW$

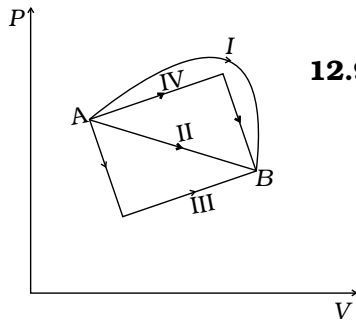


Fig. 12.5

**12.9** Figure 12.5 shows the  $P$ - $V$  diagram of an ideal gas undergoing a change of state from  $A$  to  $B$ . Four different parts I, II, III and IV as shown in the figure may lead to the same change of state.

- (a) Change in internal energy is same in IV and III cases, but not in I and II.
- (b) Change in internal energy is same in all the four cases.
- (c) Work done is maximum in case I
- (d) Work done is minimum in case II.

**12.10** Consider a cycle followed by an engine (Fig. 12.6)

- 1 to 2 is isothermal
- 2 to 3 is adiabatic
- 3 to 1 is adiabatic

Such a process does not exist because

- (a) heat is completely converted to mechanical energy in such a process, which is not possible.
- (b) mechanical energy is completely converted to heat in this process, which is not possible.
- (c) curves representing two adiabatic processes don't intersect.
- (d) curves representing an adiabatic process and an isothermal process don't intersect.

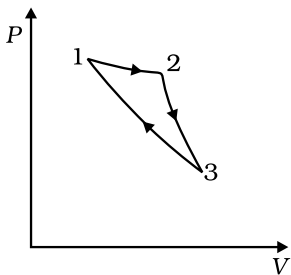


Fig. 12.6

**12.11** Consider a heat engine as shown in Fig. 12.7.  $Q_1$  and  $Q_2$  are heat added to heat bath  $T_1$  and heat taken from  $T_2$  in one cycle of engine.  $W$  is the mechanical work done on the engine.

If  $W > 0$ , then possibilities are:

- (a)  $Q_1 > Q_2 > 0$
- (b)  $Q_2 > Q_1 > 0$
- (c)  $Q_2 < Q_1 < 0$
- (d)  $Q_1 < 0, Q_2 > 0$

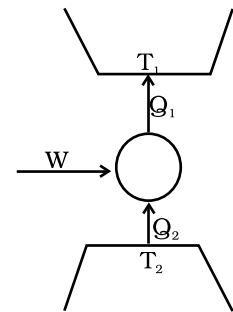


Fig. 12.7

## VSA

- 12.12** Can a system be heated and its temperature remains constant?
- 12.13** 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?
- 12.14** If a refrigerator's door is kept open, will the room become cool or hot? Explain.
- 12.15** Is it possible to increase the temperature of a gas without adding heat to it? Explain.
- 12.16** Air pressure in a car tyre increases during driving. Explain.

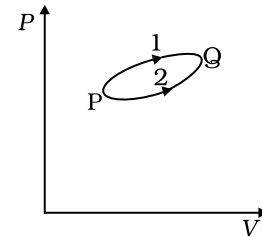


Fig. 12.8

## SA

- 12.17** Consider a Carnot's cycle operating between  $T_1 = 500\text{K}$  and  $T_2 = 300\text{K}$  producing 1 kJ of mechanical work per cycle. Find the heat transferred to the engine by the reservoirs.
- 12.18** 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?
- 12.19** 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  $\Delta V (\ll V)$  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  $P_2$ ?
- 12.20** 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  $-3^\circ\text{C}$  to  $27^\circ\text{C}$ , find the heat taken out of the refrigerator per second assuming its efficiency is 50% of a perfect engine.

 Exemplar Problems-Physics

**12.21** If the co-efficient of performance of a refrigerator is 5 and operates at the room temperature ( $27^\circ\text{C}$ ), find the temperature inside the refrigerator.

**12.22** The initial state of a certain gas is  $(P_1, V_1, T_1)$ . It undergoes expansion till its volume becomes  $V_2$ . Consider the following two cases:

- the expansion takes place at constant temperature.
- 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?

### LA

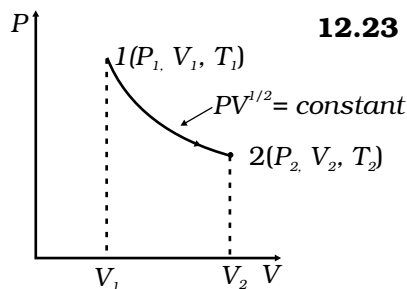


Fig. 12.9

**12.23** 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.

- Find the work done when the gas is taken from state 1 to state 2.
- What is the ratio of temperature  $T_1/T_2$ , if  $V_2 = 2V_1$ ?
- 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  $V_2 = 2V_1$ .

**12.24** 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.

A to B : volume constant

B to C : adiabatic

C to D : volume constant

D to A : adiabatic

$$V_C = V_D = 2V_A = 2V_B$$

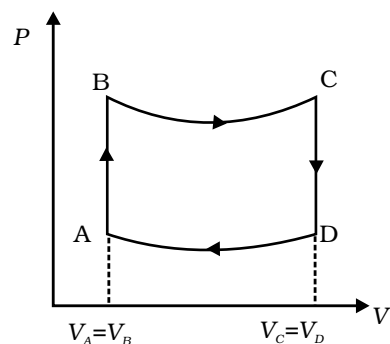


Fig. 12.10

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

$$[\gamma = 5/3 \text{ for the gas}], (C_v = \frac{3}{2}R \text{ for one mole})$$

- 12.25** 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. ( $C_v = (3/2)R$ )

- AB : constant volume  
 BC : constant pressure  
 CD : adiabatic  
 DA : constant pressure

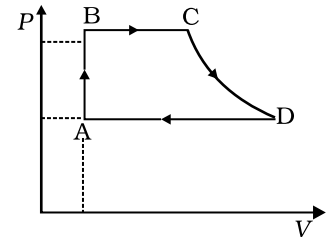


Fig. 12.11

- 12.26** Consider that an ideal gas ( $n$  moles) is expanding in a process given by  $P = f(V)$ , which passes through a point  $(V_0, P_0)$ . Show that the gas is absorbing heat at  $(P_0, V_0)$  if the slope of the curve  $P = f(V)$  is larger than the slope of the adiabat passing through  $(P_0, V_0)$ .

- 12.27** 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  $V_0$  to  $V_1$ .

- (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  $Q$ ,  $P_a$ ,  $V$ ,  $V_0$  and  $k$ .

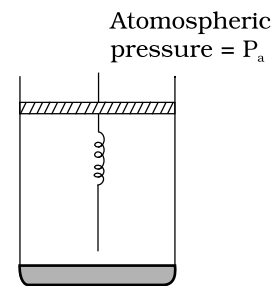


Fig. 12.12